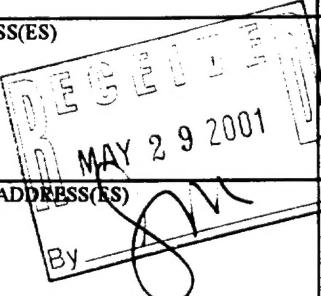


# REPORT DOCUMENTATION PAGE

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1. AGENCY USE ONLY (Leave Blank)		2. REPORT DATE April 26, 2001	3. REPORT TYPE AND DATES COVERED <i>Final Report 01 Jul 98 - 31 Dec 00</i>
4. TITLE AND SUBTITLE Tunable Evanescent Mode Filters		5. FUNDING NUMBERS DAAG55-98-1-420	
6. AUTHOR(S) Linda P. B. Katehi		8. PERFORMING ORGANIZATION REPORT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Michigan Room 3120, EECS Bldg. 1301 Beal Ave. Ann Arbor, MI 48109		9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)  U. S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211	
10. SPONSORING / MONITORING AGENCY REPORT NUMBER 38887-EL			
11. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.			
12 a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited.		12 b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) A single pole evanescent resonator has been designed and built under to test feasibility. The results are shown in Figure 9 and indicate that the filter structure resonates at 3 GHz and has a Q of 460. Due to the lumped element character of the evanescent mode micromachined structure, parasitic resonances do not exist as shown by the measured and theoretically calculated data. As shown by Figure 9, only one resonance from 0 to 20 exists. Higher order periodic resonance are suppressed by the cutoff of the guide and the presence of the post. Using a similar synthesis method, a 2-pole bandpass filter has been designed and simulated at X band. The volume of the designed filter is 10.5 mm <sup>3</sup> compared to a 400 mm <sup>3</sup> 2-pole micromachined resonant cavity filter with comparable performance. To add extra poles to an evanescent filter, additional posts separated by evanescent cavities are needed. This makes multiple pole filters easy to fabricate since only two silicon wafers are needed to create the cavity. The capability to fabricate these filters using IC fabrication techniques [5,6] allows for unique designs that may reduce size even further.			
14. SUBJECT TERMS Mode Filters		15. NUMBER OF PAGES	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OR REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION ON THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL
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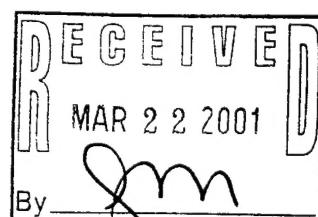
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**EVANESCENT MODE FILTERS**

By

**LINDA P.B. KATEHI**

The University of Michigan  
Ann Arbor



Hand delivered  
by B. Webster...

February 2001

## PROJECT DESCRIPTION

### A. INTRODUCTION

Typical communication satellites, Figure 1, employ traditional waveguide-base front-end architectures due to excellent electrical performance and high reliability. However, these systems are extremely massive and utilize large volume mostly attributed to the low-insertion loss waveguide switch, diplexer and waveguide-packaged solid-state power amplifier. These three components are interconnected by waveguide sections for compatibility and result in subsystems with dimensions of 18cm x 40.6 cm x 10.5 cm as shown on Figure 2. Despite the large volume and mass, metallic waveguide has been the transmission medium of choice in space applications due to the low-loss requirements. Its use in communication systems has resulted in overall system loss of less than 2 dBs. Replacement of the waveguide components by micro-machined ones without substantially affecting electrical performance can lead to a breakthrough in wireless communications [1], [2]. Communications via satellites require optimum high frequency performance, lightweight hardware, advanced packaging, high-density interconnect technology and high reliability. The use of electronics in space poses interesting but grand challenges. It also provides the opportunity for using revolutionary concepts in circuit design, fabrication and implementation to achieve what is considered by today's standards as ultimate performance, minimal volume and very low cost. Circuit optimization methods applied to existing technologies cannot meet the specifications, but critical advancements based on new concepts at fundamental levels of circuit design and diagnostics are needed. The capability to integrate the RF system on a single chip while preserving electrical performance will provide a breakthrough in communications systems for any type of wireless applications. The objectives of this effort is to attempt a revolutionary filter/diplexer design by combining on-wafer integration and packaging along with micromachined waveguide-like structures into a single monolithic arrangement that exhibits very high Q and very small size. In addition, this monolithic filter/diplexer will have the ability to electronically achieve reconfigurable performance using MEMS devices. Such a device will provide desired RF filtering in addition to frequency hopping and can be used in filter banks due to very small size. While not as small as microelectrical mechanical filters [4], the proposed filter devices will have a size of the order of a few millimeters for operation in the low end of the microwave spectrum. This size is considerably smaller than that of any other conventional filter

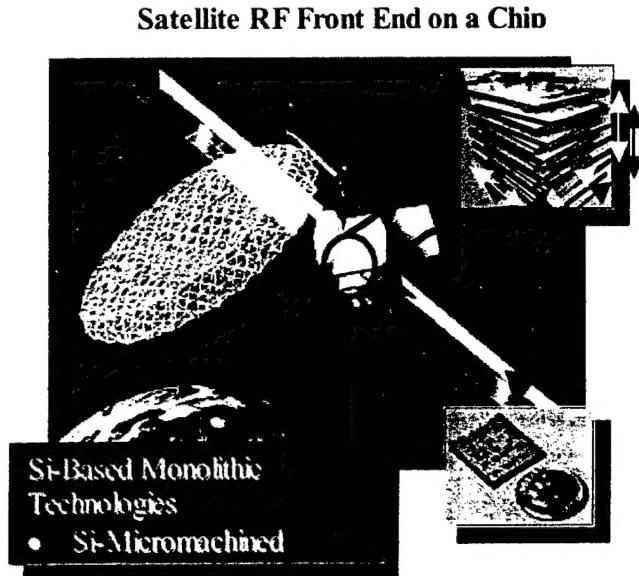


Figure 1: Waveguide-Based Satellite RF Front End

of similar performance. Furthermore these filters can be integrated monolithically with the conventional planar technology while they provide the smallest possible size along with excellent performance for frequency ranges above 1-2 GHz. The filters proposed herein are equivalent to lumped element filters where the lumped L and C is provided by appropriate use of micromachined shapes. This is the underlining concept that leads to drastic reduction of size. To accomplish this goal advanced electronics material technology and high-density fabrication techniques along with electromagnetic analysis tools will be used. The development of such a diplexer will demonstrate a key concept in advanced communications architectures and systems and it will have a major impact on wireless technologies.

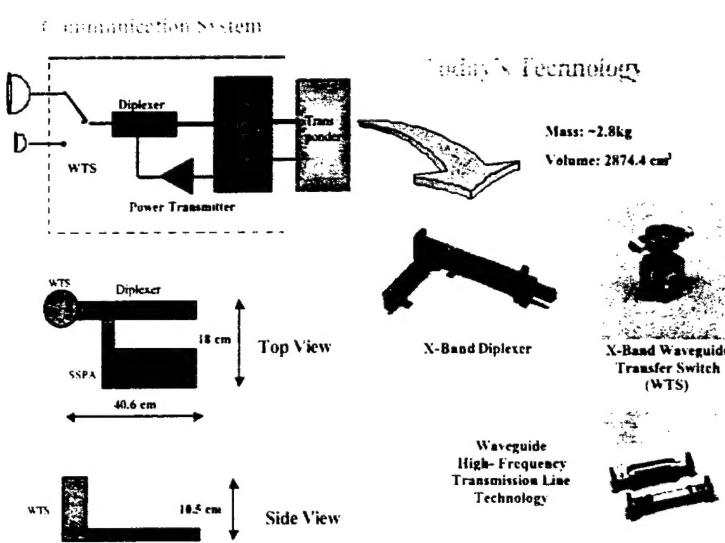


Figure 2: Conventional Waveguide RF Front-End

- to the size of the resulting filter and because the achieved Q cannot exceed 500 [1,2].
- Si micromachined resonator cavity filters can be integrated monolithically and can provide filters with drastically reduced height (1-1.5mm). However, the use of resonating cavities limits the transverse size of the filter to a minimum of half free-space wavelengths (about 1.5mm in W band, 1.5cm in X band and 5 cm in L Band) [3].
- The need to acquire high Q and small size for frequencies in the low end of the microwave spectrum, requires the use of non-resonant monolithically integrated structures.
- Small size and high Q may require frequency and input match adjustments. Such adjustments, while necessary in the case of very high-Q filters, are impossible without the use of MEMS.
- The ability to electronically adjust frequency and bandwidth will provide additional filter functionality such as tunability, switching and frequency hopping that will lead to new architectures in communication systems.

Based on the above observations we concluded that small size, high-Q filters or filter banks with high isolation between the adjacent channels can be achieved by use of micromachined evanescent-mode cavities that appropriately couple to each other and to the input/output microstrip or coplanar waveguide transmission lines. The use of evanescent mode structures provides small size and the ability to tune via small variations in some geometrical parameters using MEMS structures. Studies performed at Michigan under ARO/DARPA funding have demonstrated the potential of this filter technology to provide excellent performance and very small size. While, high isolation between the adjacent channels is intrinsic to this filter design,

## B. SUMMARY OF PERFORMED STUDY

The design of a diplexer reduces to a filter design with two very narrow communication frequency channels highly isolated. The study performed during the past few years at Michigan has demonstrated the following [1-6]:

- In monolithic filter designs high-Q performance can only be achieved by use of filters that include either resonating elements printed on membranes or micro-machined waveguide resonant cavities (Figure 3).
- The use of membrane filters is limited to high frequencies due

further improvements can be achieved by use of the on-wafer packaging techniques, which have demonstrated the ability to provide isolation as high as -80dB to -100 dB [4-6].

The performed study focused on the development of evanescent mode resonators and filters using micromachined cavities in S, L and X Bands. A detailed description of the effort in each one of these two steps is given below.

### Evanescence-mode Micromachined Filters

Historically, the development of microwave passive networks consists mainly of finding distributed components which can provide inductive and capacitive reactances to replace the lumped elements employed by the filter prototype. Although distributed constant networks are necessary for high-Q reactance elements, it is not essential that these networks be based on structures of the conventional transmission line type. For some years now literature has been accumulating on network designs using waveguide sections below their cut-off frequency [17,18]. Lebedev and Guttsait [18] first discovered that resonant behavior can be achieved by any evanescent mode if appropriate terminating conditions (a conjugate reactance) for that mode are provided.

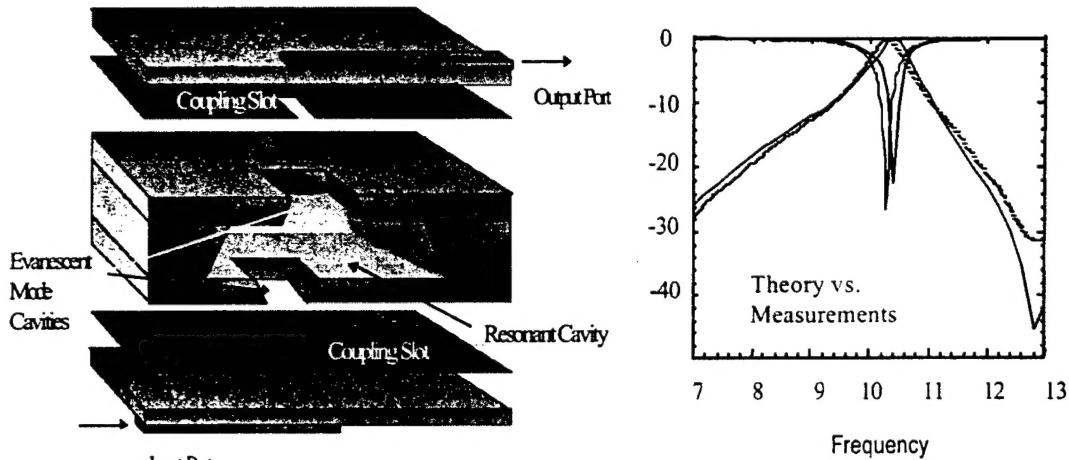
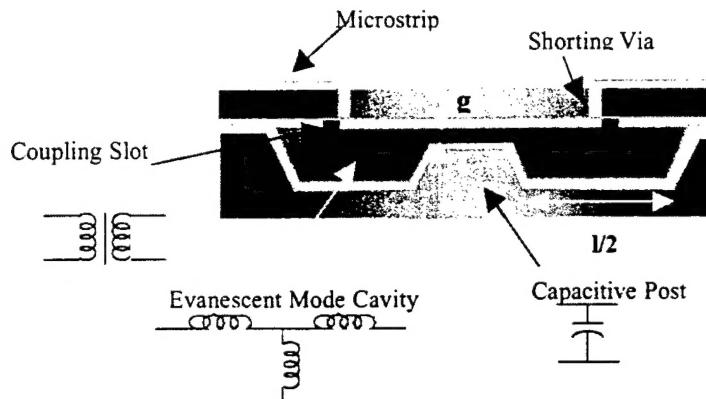
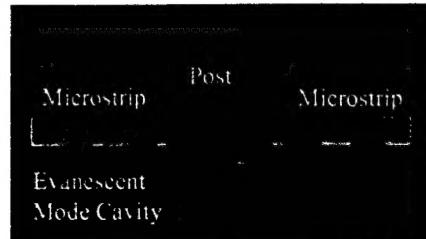


Figure 4: Single-Pole Micromachined Filter with Evanescent and Resonant Cavities. Theoretically Calculated Q=569, Measured Q=530. Insertion Loss at Center Frequency IL=.3dB, BW=5%.

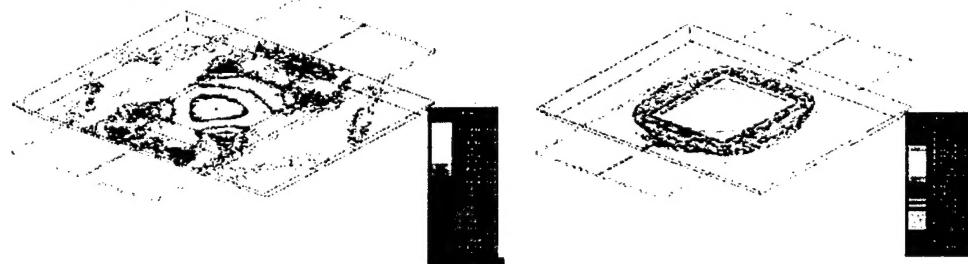
Any band-pass filter can be realized from a low-pass prototype by appropriate frequency and impedance scaling. The band-pass prototype can then be converted to a lumped element configuration where shunt LC resonators are connected through admittance inverters. It can be proven that this circuit can reduce into a sequence of evanescent waveguide sections appropriately connected by negative (capacitive) coupling. This negative coupling can be provided by resonating cavities as shown in Figure 4 [17] or by capacitive obstacles as shown in Figure 5. Preliminary results have demonstrated the ability to provide very high Q using resonant cavities (see Figure 6). While this approach results in filters that compare to waveguide ones in terms of performance requirements, the size of the resonating cavities may prohibit operation at lower frequencies. Specifically for a 5%, X-band single pole filter, the size of the resonating cavity is 15mm (width) x 20mm (length) x 0.5mm (height). The same filter scaled to 2.5 GHz would require a length of 8 cm and a width of 6 cm.



**Magnetic Field Patterns of an Evanescent Mode**



**H-Field Distribution in the Evanescent Mode Sect**



**Figure 6:Single Pole Evanescent Mode Filter**

When size becomes an issue, the evanescent mode filter of Figure 5 is an appropriate solution where by use of capacitive obstacles such as the pyramidal posts, shown in the figure, required filter size is reduced considerably. As part of this effort we will demonstrate the use of this approach in the development of S- and X- band tunable filters and we will evaluate the effectiveness of the design in terms of size, Q, bandwidth and loss.

The lumped element equivalent to the inductive section (evanescent mode section) of guide is that of a transmission line with imaginary impedance and leads to the development of effective lumped element models. For a single pole evanescent mode filter the lumped element models are shown in Figures 6 and 7. Empirical formulas for the capacitance and inductance of the variable height post have been developed using quasi-static techniques and have been verified by a high-frequency simulator, Ansoft's HFSS. These formulas can be utilized to design an evanescent

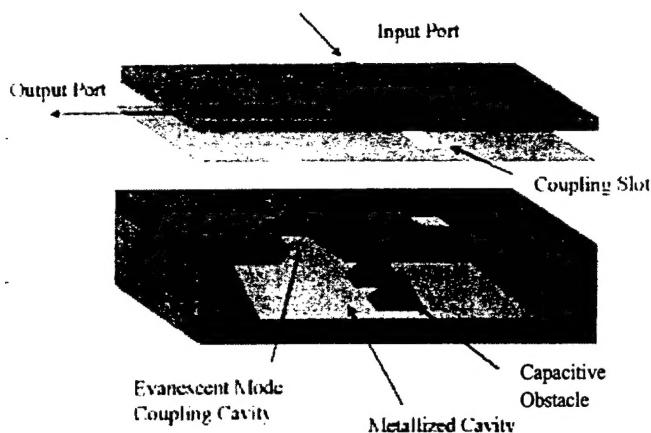
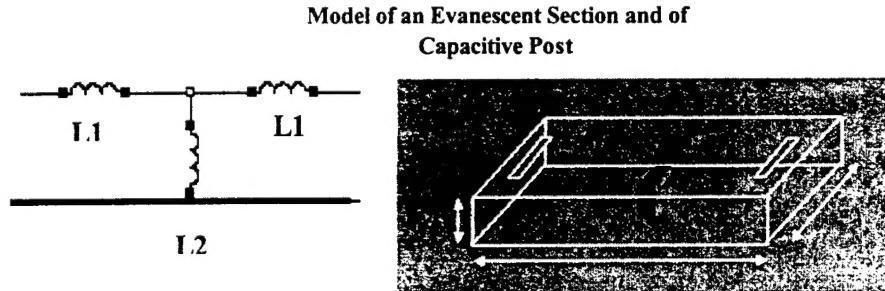


Figure 5: Evanescence Mode Filter with Capacitive Posts

feasibility. The results are shown in Figure 9 and indicate that the filter structure resonates at 3 GHz and has a Q of 460. Due to the lumped element character of the evanescent mode micromachined structure, parasitic resonances do not exist as shown by the measured and theoretically calculated data. As shown by Figure 9, only one resonance from 0 to 20 exists. Higher order periodic resonance are suppressed by the cutoff of the guide and the presence of the post. Using a similar synthesis method, a 2-pole bandpass filter has been designed and simulated at X band. The volume of the designed the filter is 10.5 mm<sup>3</sup> compared to a 400 mm<sup>3</sup> 2-pole micromachined resonant cavity filter with comparable performance. To add extra poles to an evanescent filter, additional posts separated by evanescent cavities are need. This makes multiple pole filters easy to fabricate since only two silicon wafers are needed to create the cavity. The capability to fabricate these filters using IC fabrication techniques [5,6] allows for unique designs

multi-pole filter from the standard low-pass designs. In addition, from these simple formulas trends may be developed to predict changes in filter response, center frequency and bandwidth, by inducing small changes in dimensions, as shown in Figure 8. Understanding these trends is very important to electronic tuning via use of MEMS devices

A single pole evanescent resonator has been designed and built under to test



$$Z_{cavity} = \frac{Z_0}{w \cdot \sinh[\gamma_e \cdot \frac{l}{2}]}$$

$w$ =Radial Frequency  
 $\lambda$ =Free Space Wavelength  
 $\lambda_c$ =Cutoff Wavelength of The Guide  
 $k$ =Wavenumber  
 $Z_0$ =Free Space Impedance (120 Ω)  
 $K$ =Proportionality Constant

$$L_1 = \frac{Z_{cavity} \tanh[\gamma_e \cdot \frac{l}{2}]}{w}$$

$$Z_{cavity} = \eta \cdot \frac{b}{a} \cdot \frac{1}{\sqrt{(\frac{\lambda}{\lambda_c})^2 - 1}}$$

$$C_{post} = K \cdot \epsilon \cdot \pi [(W_a)^{1.5} \cdot (W_x)^{1.5}]$$

$$\gamma_e = k \cdot \sqrt{(\frac{\lambda}{\lambda_c})^2 - 1}$$

Figure 7: Empirical Formulas for Evanescence Mode Sections where  $W_a$  and  $W_x$  is the Width and Length of the Capacitive Post

that may reduce size even further.

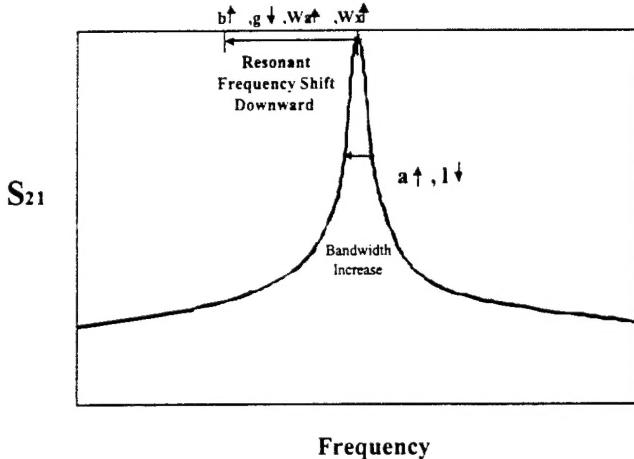


Figure 8: Trends in Filter Performance Based on Varying Geometrical Parameters

due to the high out-of-band isolation in each filter and the relative position between the two cavities.

Figure 10 indicates two possible designs for a multipole evanescent mode filter. Specifically, Figure 10a shows a three-pole evanescent mode filter with the input and output lines in a perpendicular orientation to further reduce size. The second design (Figure 10b) illustrates a possible arrangement for a diplexer with high isolation between the two output ports. This diplexer is made out of two cavities stacked vertically and coupled through a slot that has a gamma shape designed to control the coupling. This configuration is expected to have very high isolation between the two output ports

Fabricated 3 GHz, 20 by 17 by 2mm, Resonator  
Rejection of Periodic Resonance

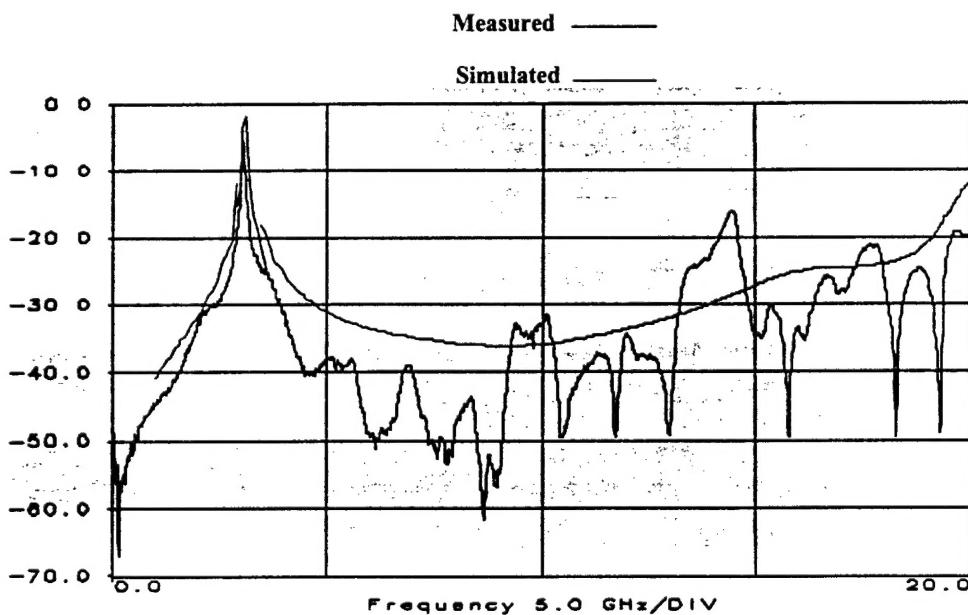


Figure 9: Measurements vs. Theory for a Single Pole Filter

While some very fast initial successes have been achieved, the full potential of the approach has not been explored. This further study is presently underway (funded by NSF) to understand the impact of tuning on the evanescent modes and their implication to filter design. Furthermore, in addition to Si, the evanescent cavities are developed using a variety of materials including electromagnetic bandgaps.

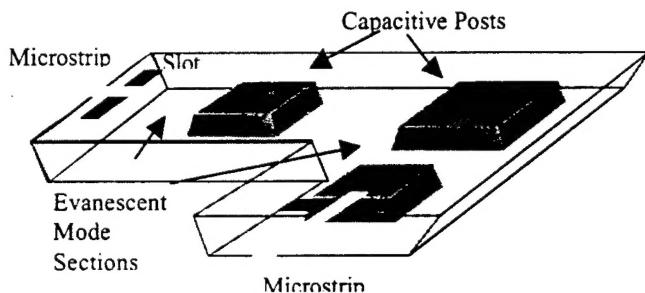


Figure 10a: Three-Pole Evanescent Mode Filter

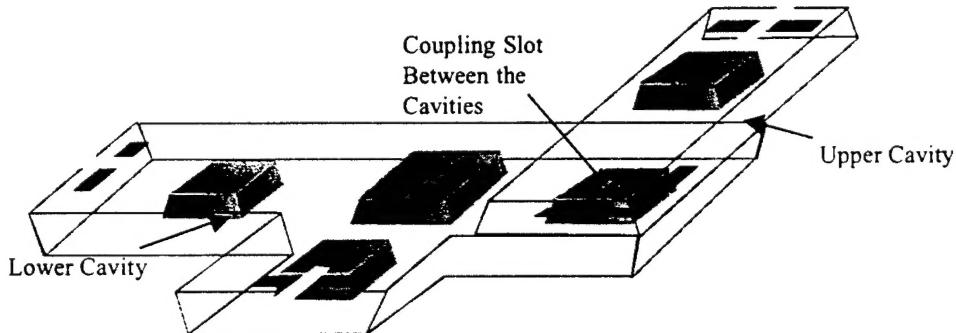


Figure 10b: Diplexer Design with Multiple Cavities Including Evanescent Mode Sections and Capacitive Posts.

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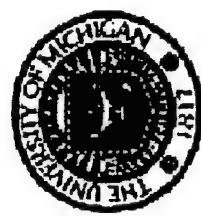
Agenda

1. FY2001 Mid-Year Financial Reports for COE Academic Departments (Mary Kurta)
2. Preliminary Financial Planning for FY2002 and Schedule for Budget/Merit Processes (Judith Pitney)
3. Supplemental Funds for Instruction (Linda Katehi)
4. Status Update of Promotion/Tenure Process (Linda Katehi)
5. Environment – Update on MIT Conference (Linda Katehi)
6. Excellence in Staff Service Awards Nominations (Steve Director)
7. Nominations for National Awards (Steve Director)



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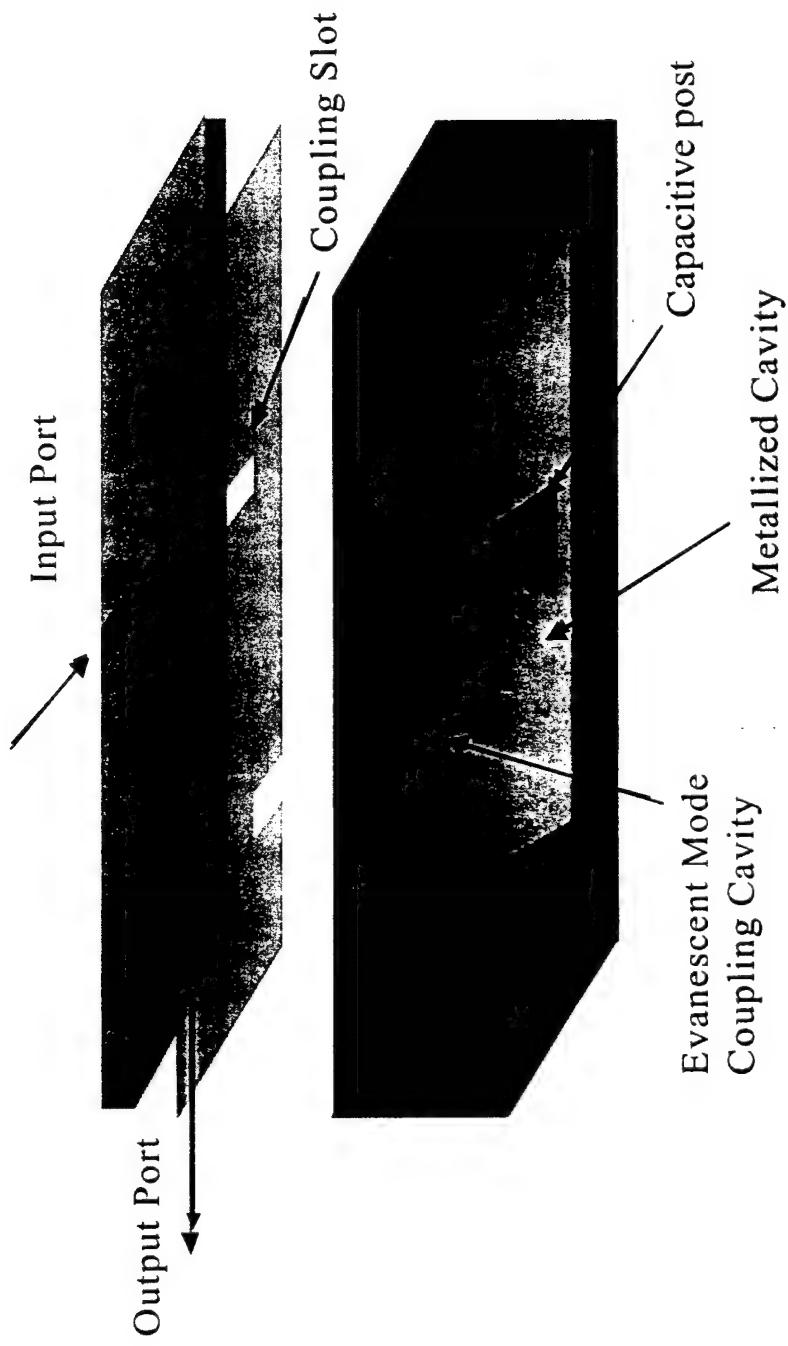


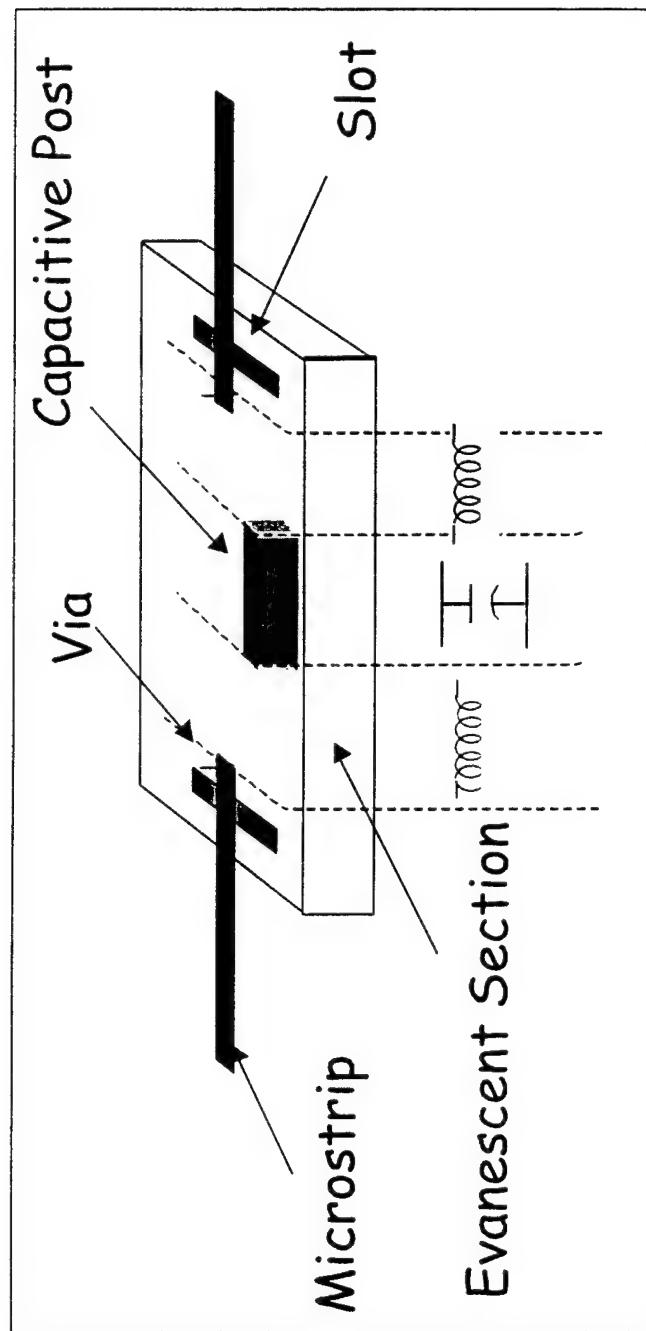
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- Identify Trade-Offs
- Develop Designs
- Fabricate and Measure to Verify





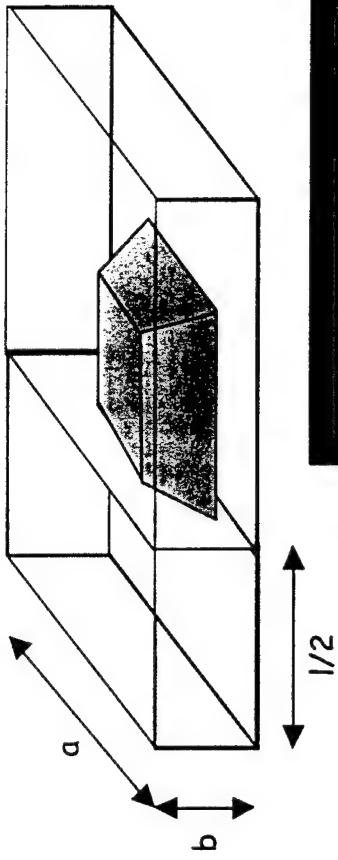
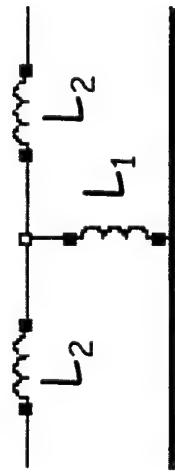




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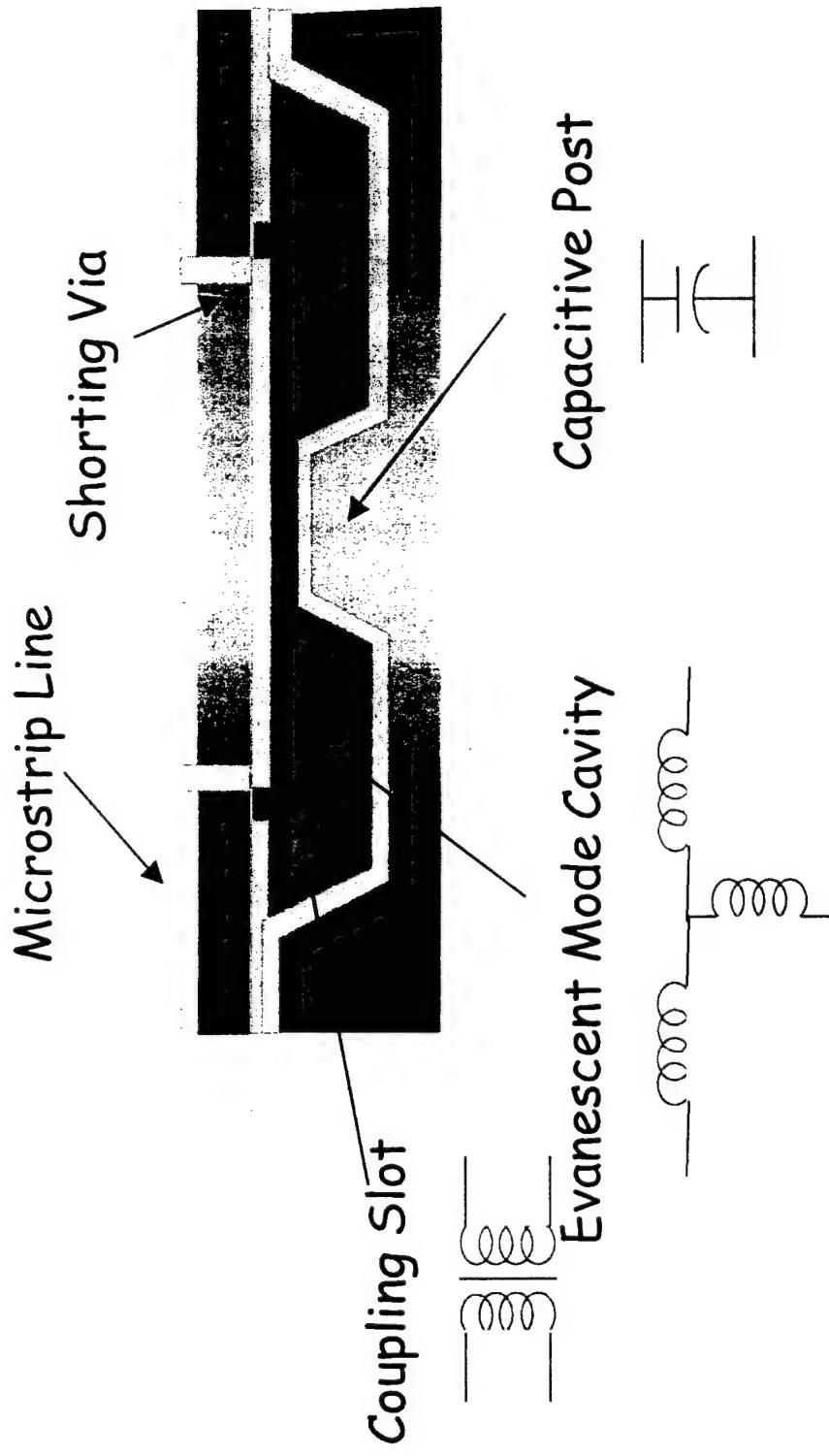
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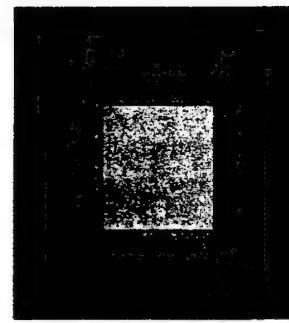
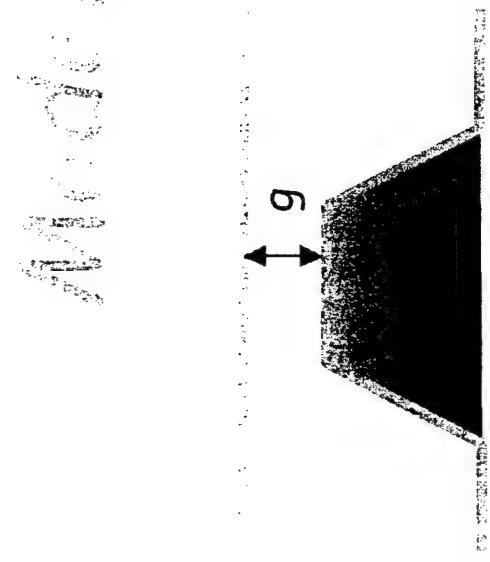
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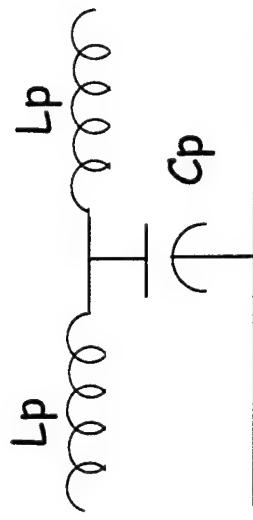




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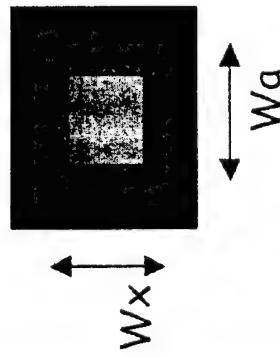
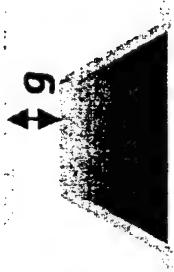
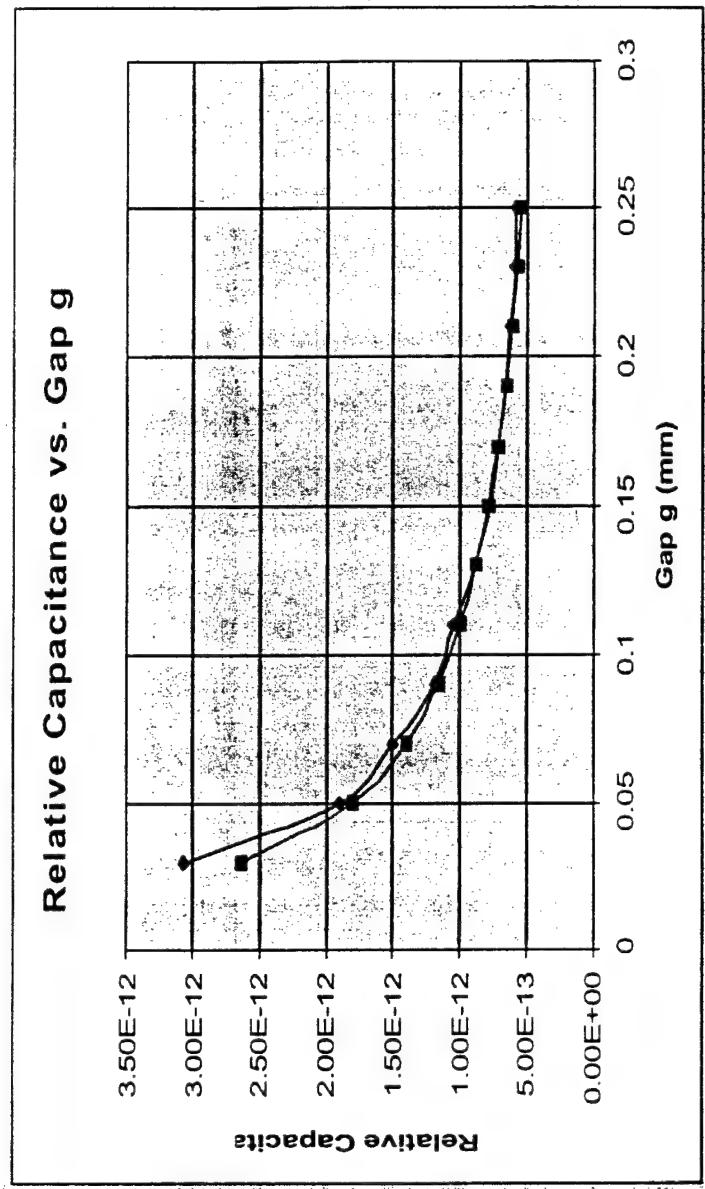


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$$C_{post} = \frac{K^* \epsilon^0 * [(W_a)^{0.63} * (W_x)^{0.33}]}{(1 - g)}$$

$$Lp = A^* [W_a^* W_x^* (1-g)] + B$$



— Quasi-Static

— Full-Wave



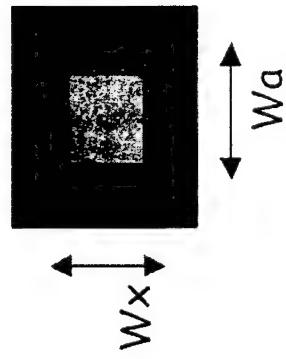
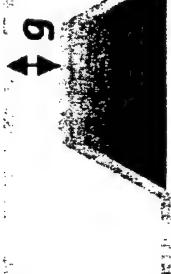
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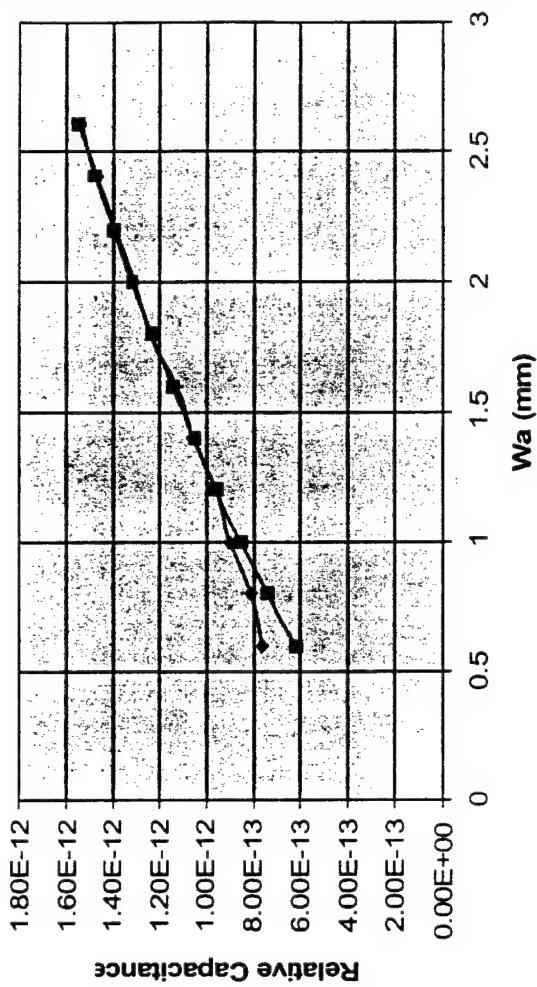
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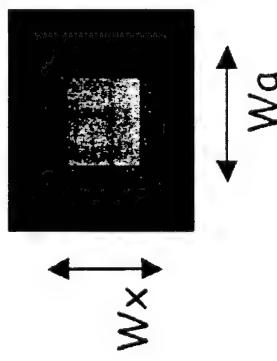
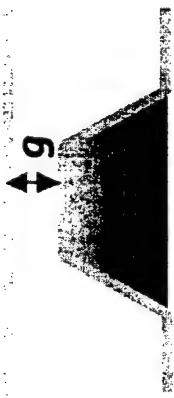
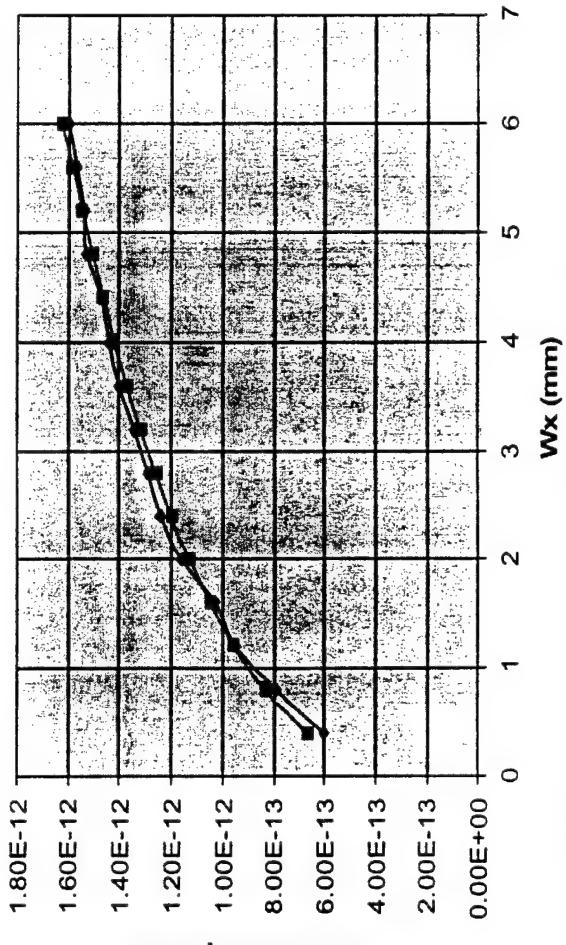
— Quasi-Static

— Full-Wave

Relative Capacitance vs.  $W_a$



### Relative Capacitance vs. $W_x$



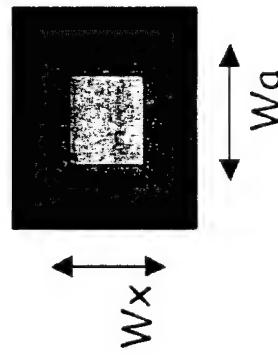
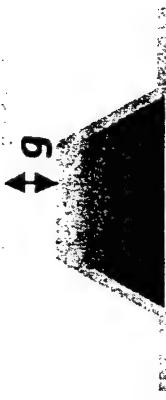
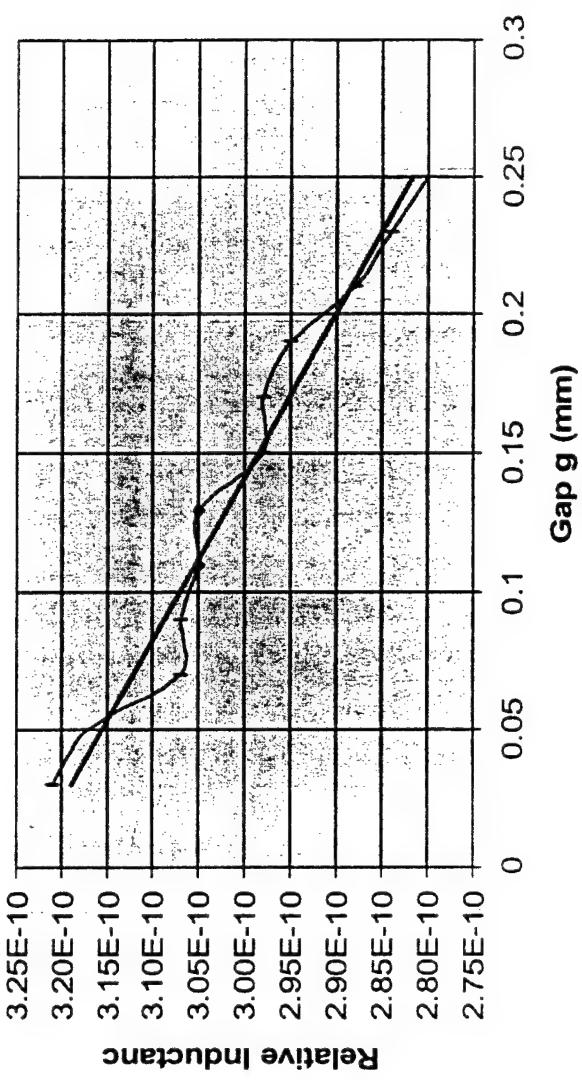
— Quasi-Static

— Full-Wave



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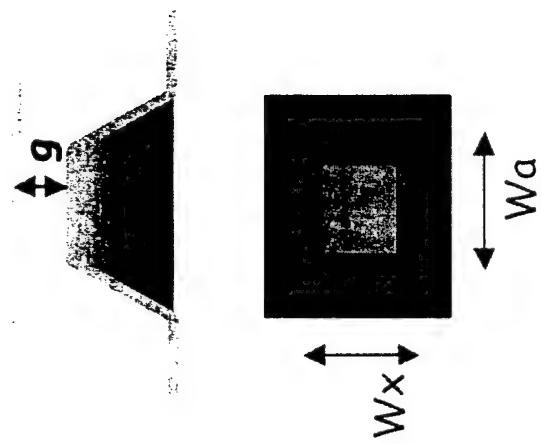
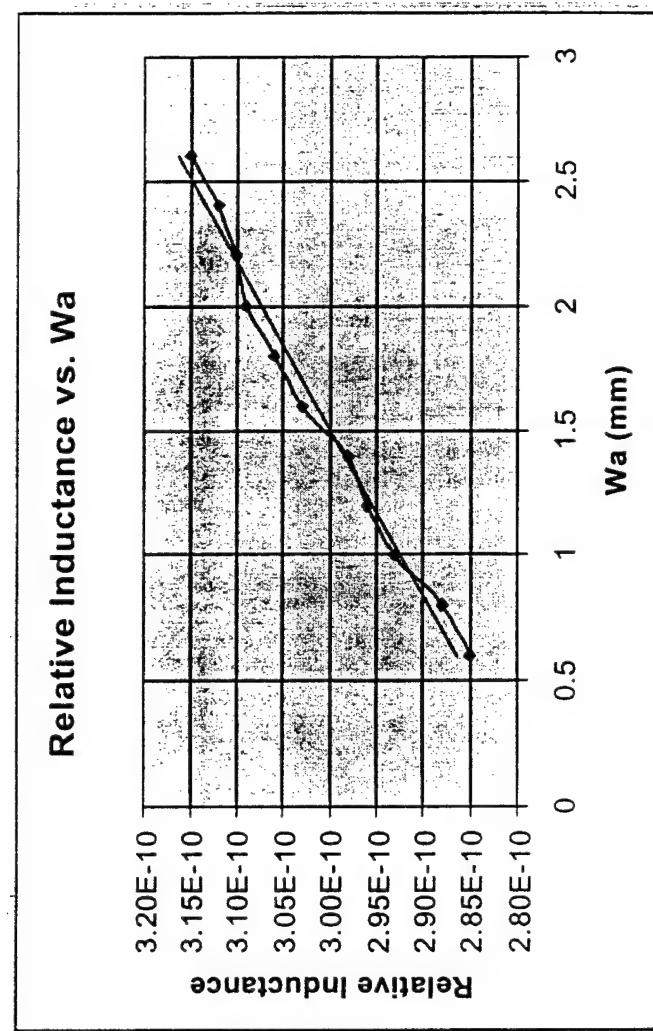
### Relative Inductance vs. Gap g



— Quasi-Static

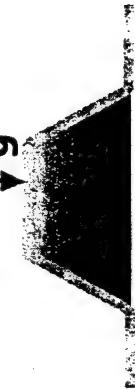
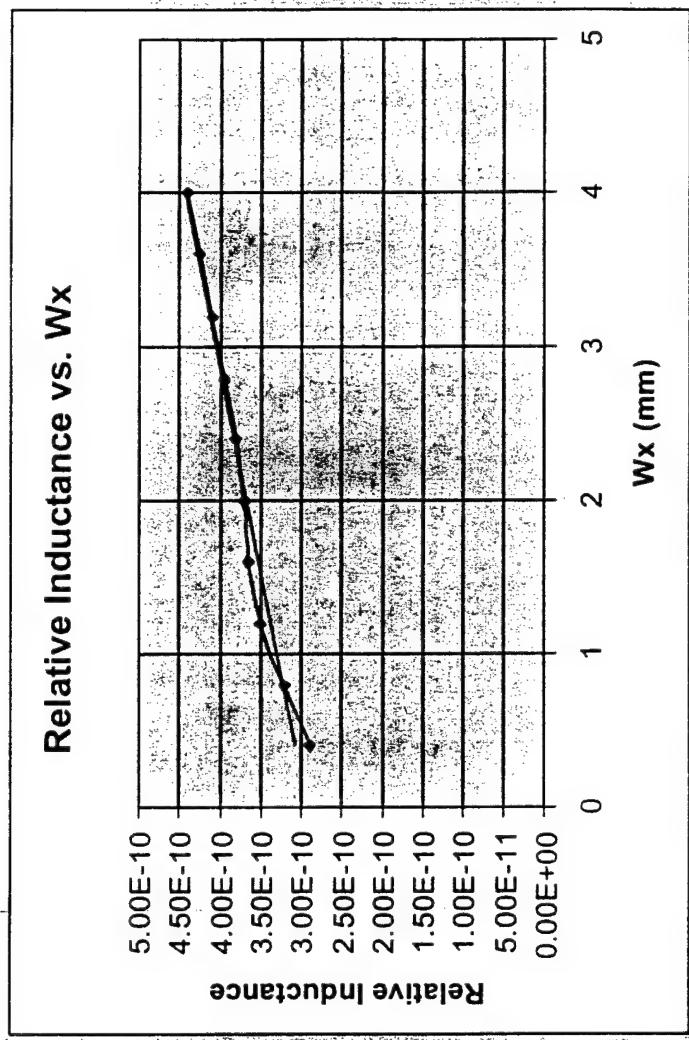
— Full-Wave





— Quasi-Static

— Full-Wave



Wx

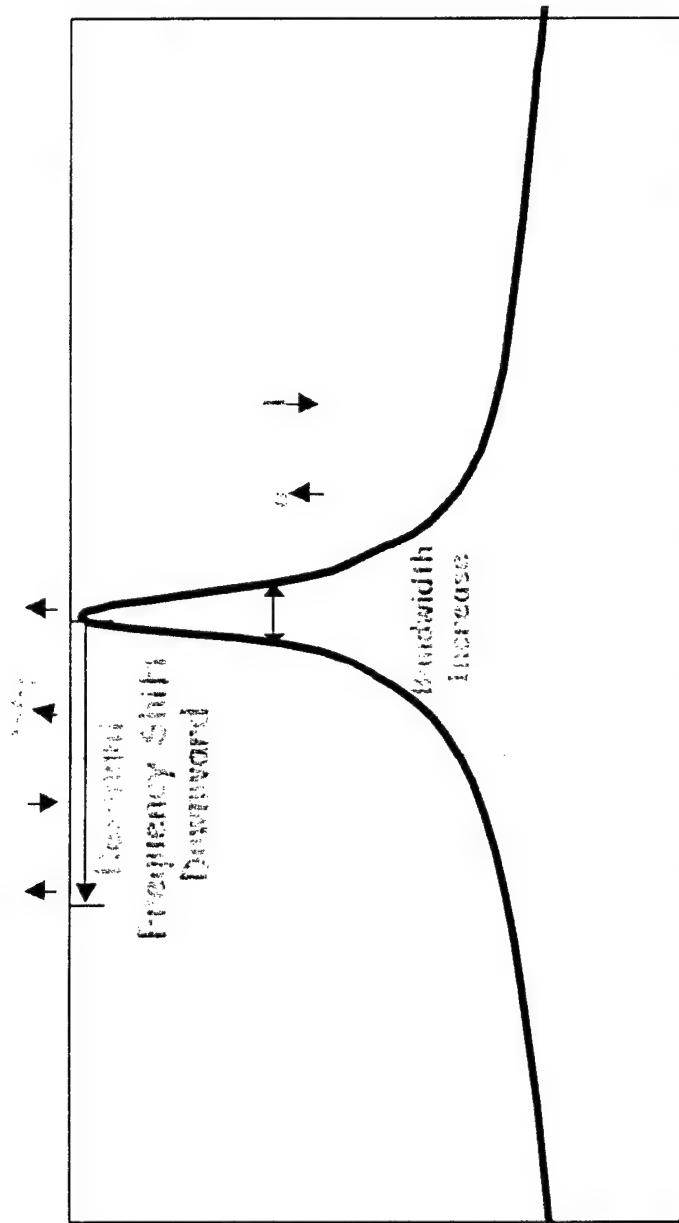
W<sub>a</sub>

Quasi-Static

Full - Wave



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6321



## S-Parameters

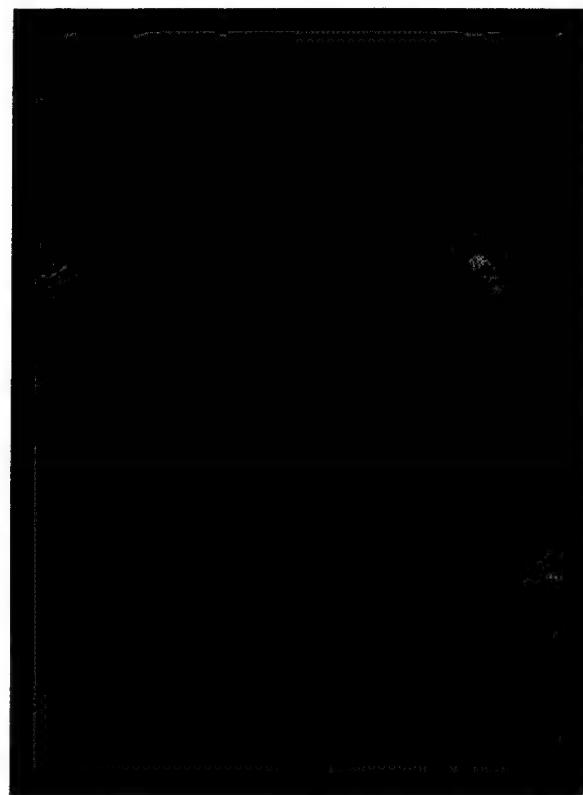
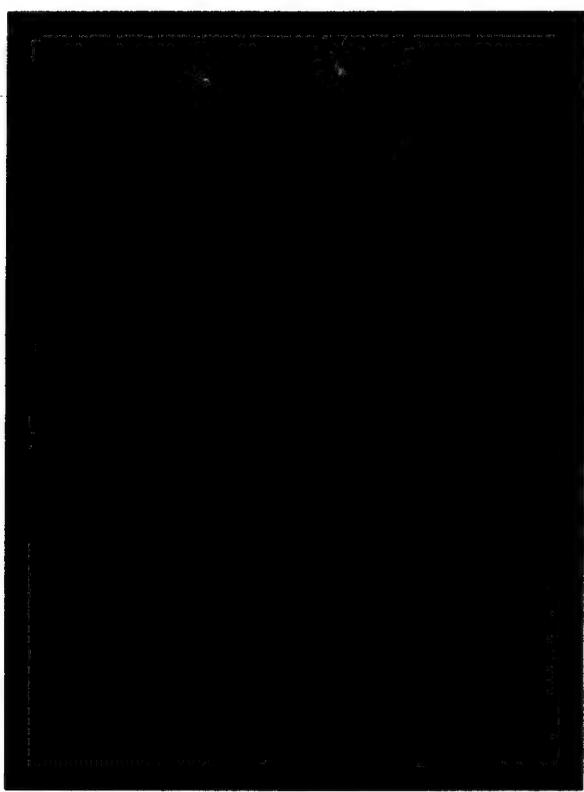


10 mm x 7 mm x 0.5 mm  
With a Q of 500



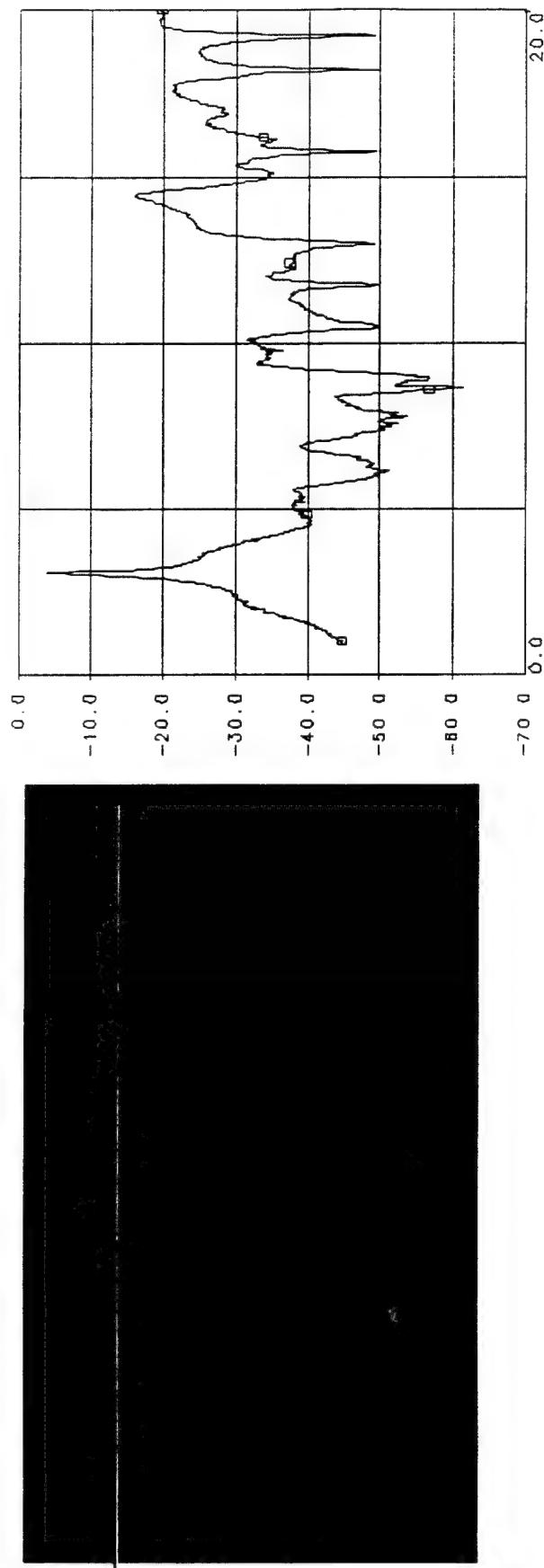


## Microwave Model



20mm x 17mm x 2mm

# Microwave Model

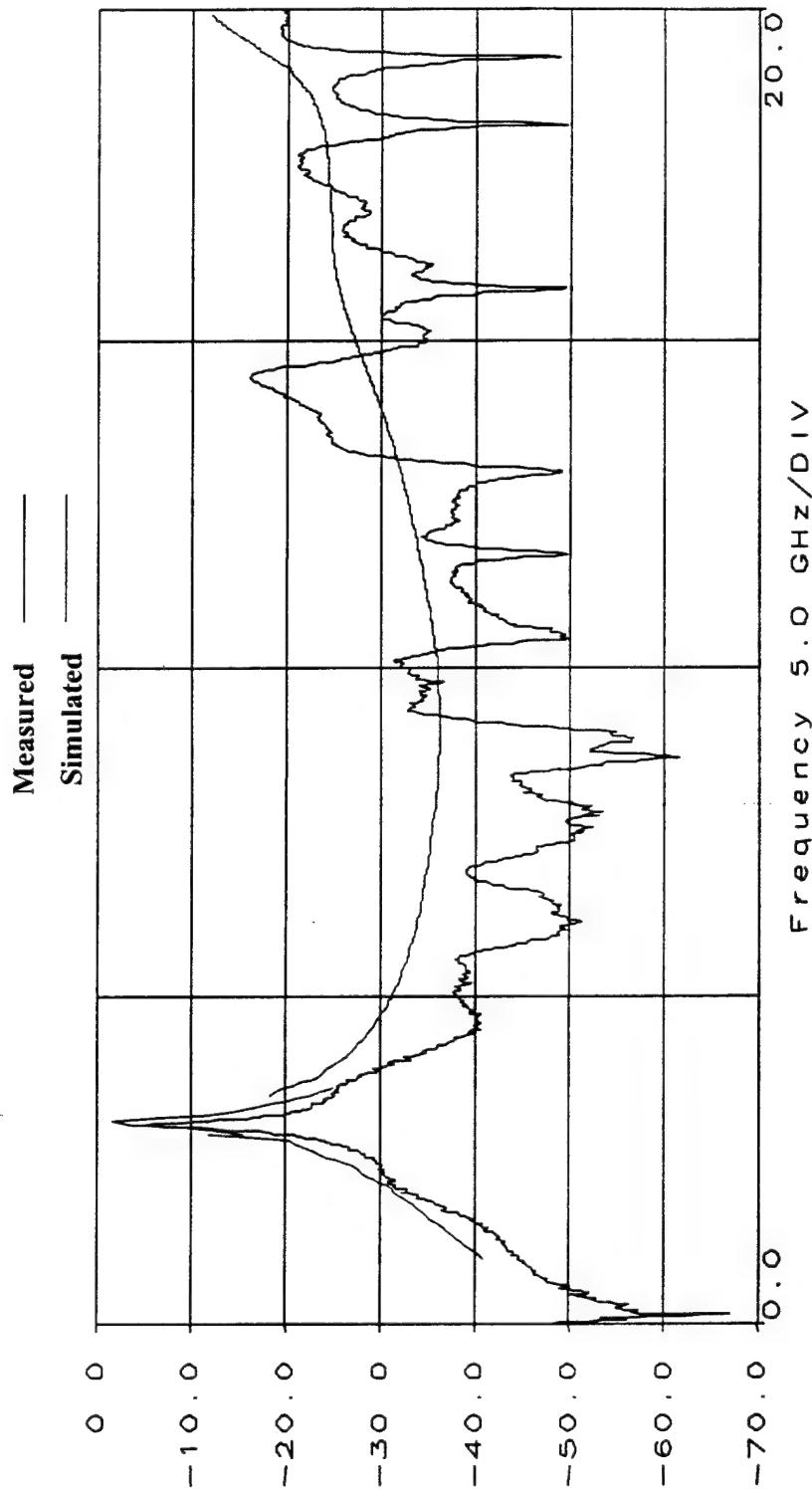


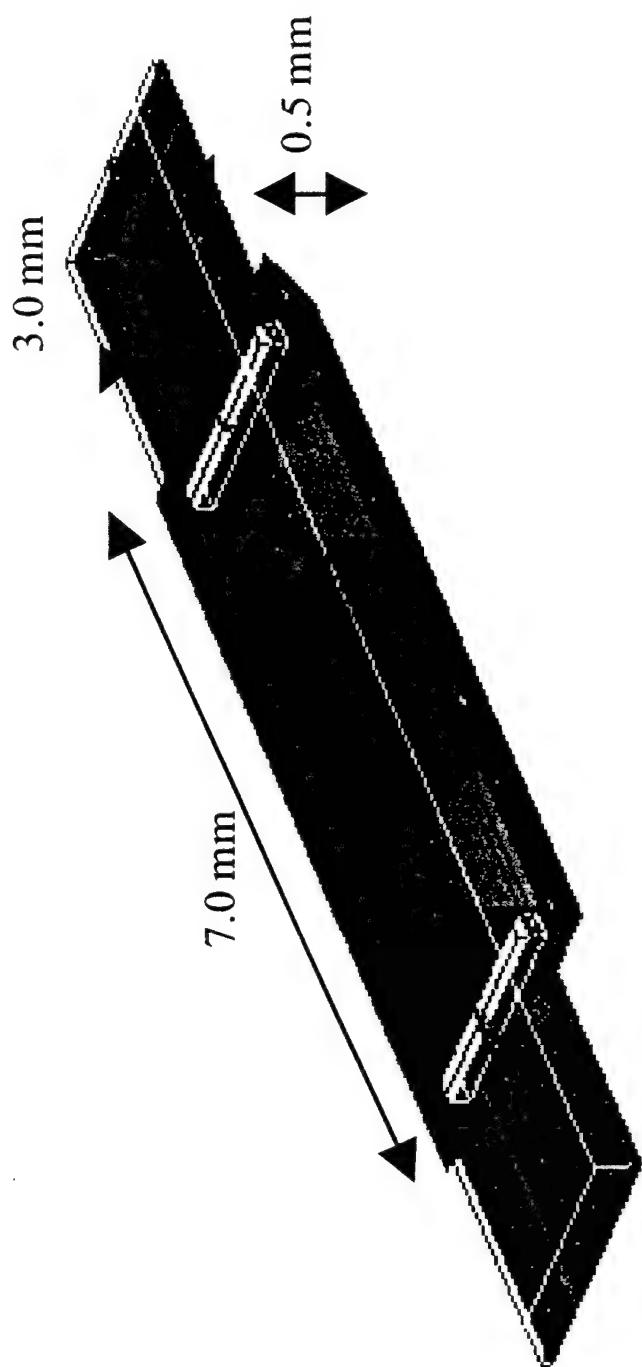
University of

Michigan  
SCHOOL OF  
AERONAUTICS  
AND ASTRONAUTICS  
DEPARTMENT OF  
AERONAUTICAL  
ENGINEERING  
AND  
AEROSPACE  
ENGINEERING



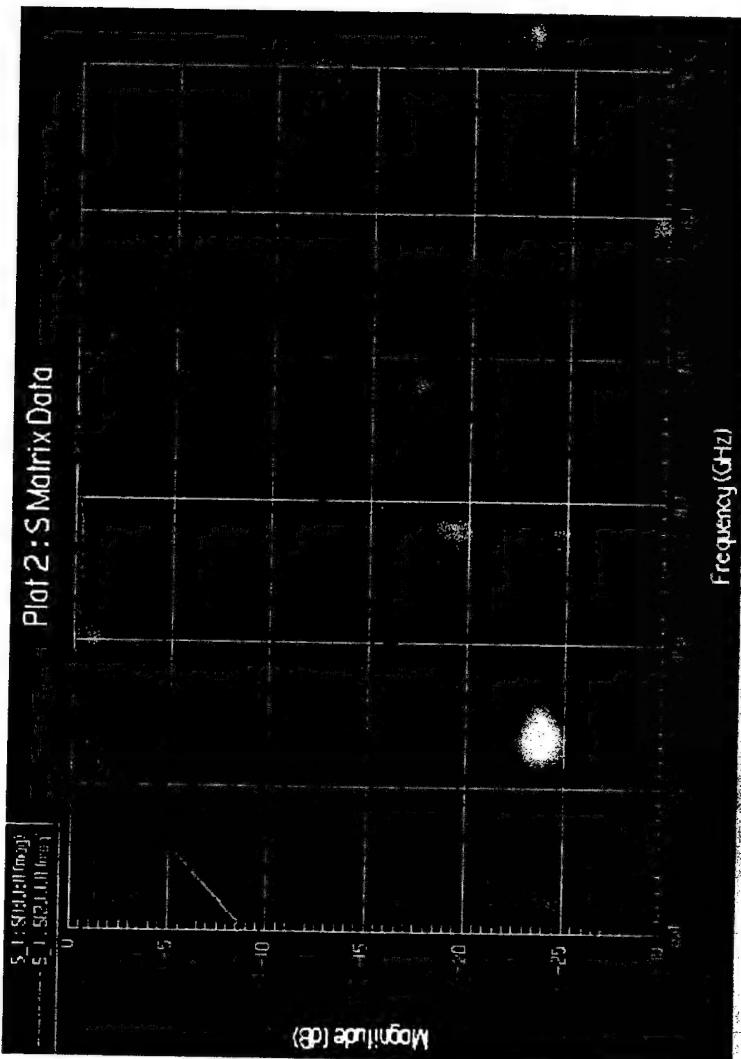
University







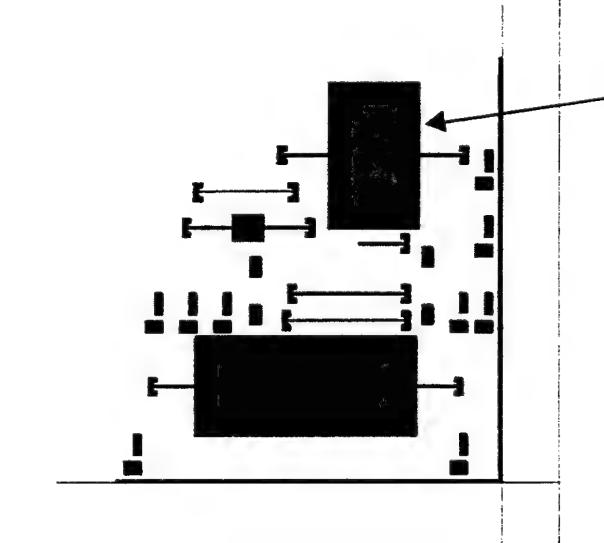
University of Michigan





University of

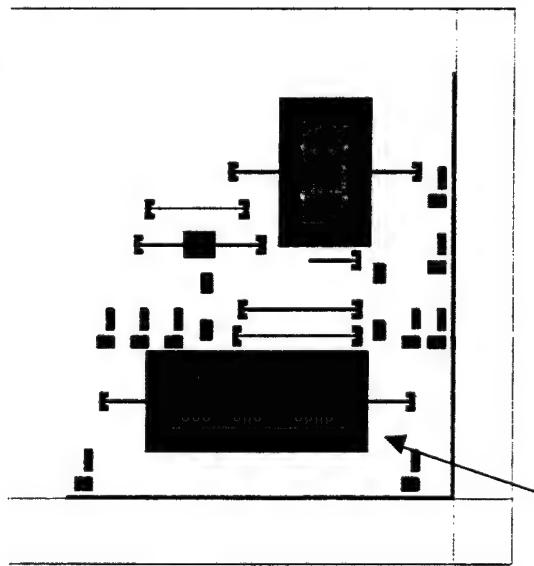
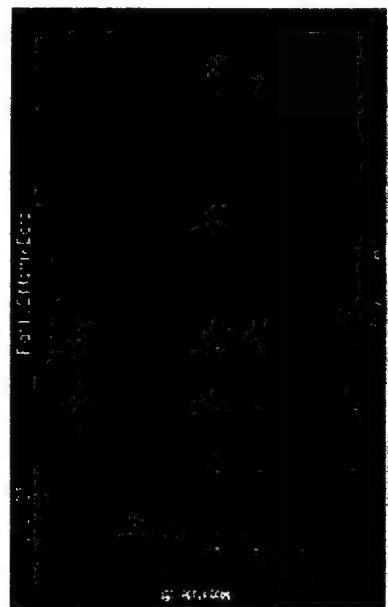
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Resonator on Mask

Expected Q =



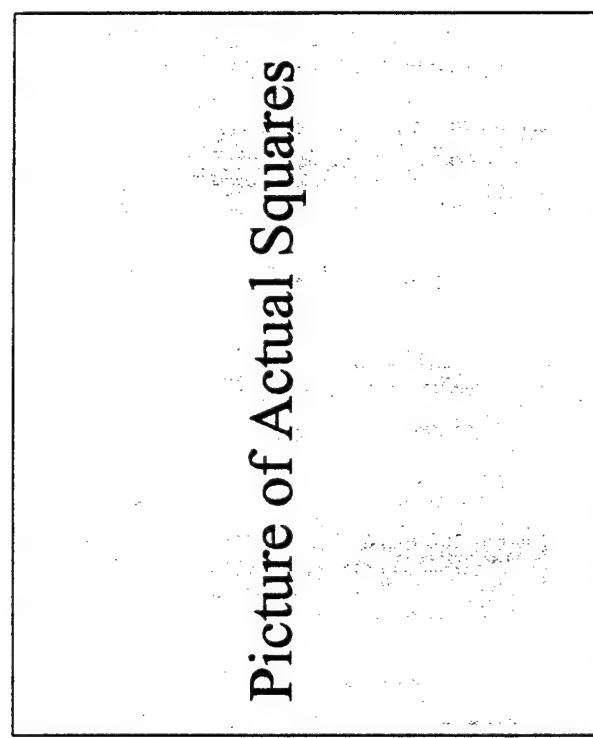


**Bandpass Filter on Mask**



**Rule is     $a=1.5 * \text{Etch Depth}$**

**Compensation Square**

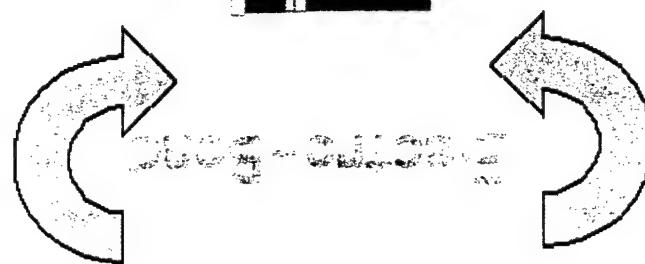




Upper Wafer



Lower Wafer





Microstrip



Coupling Slot



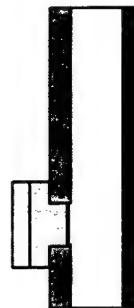
Grounding Via



Etch Vias



Pattern  $\text{SiO}_2$  &  
Sputter  $\text{Ti}/\text{Au}/\text{Ti}$



Pattern Microstrip  
& E-Plate



Pattern Slots and E-Plate

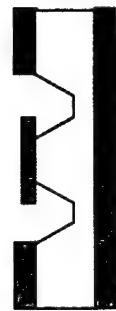
Sputter  $\text{Ti}/\text{Au}/\text{Ti}$



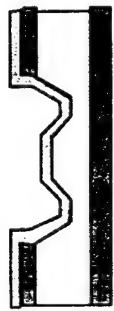
Post



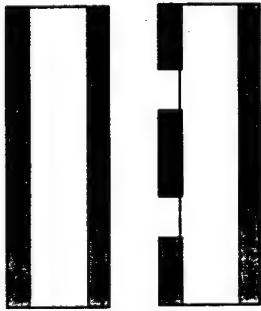
Etch Cavities



Thin Post & Sputter Gold



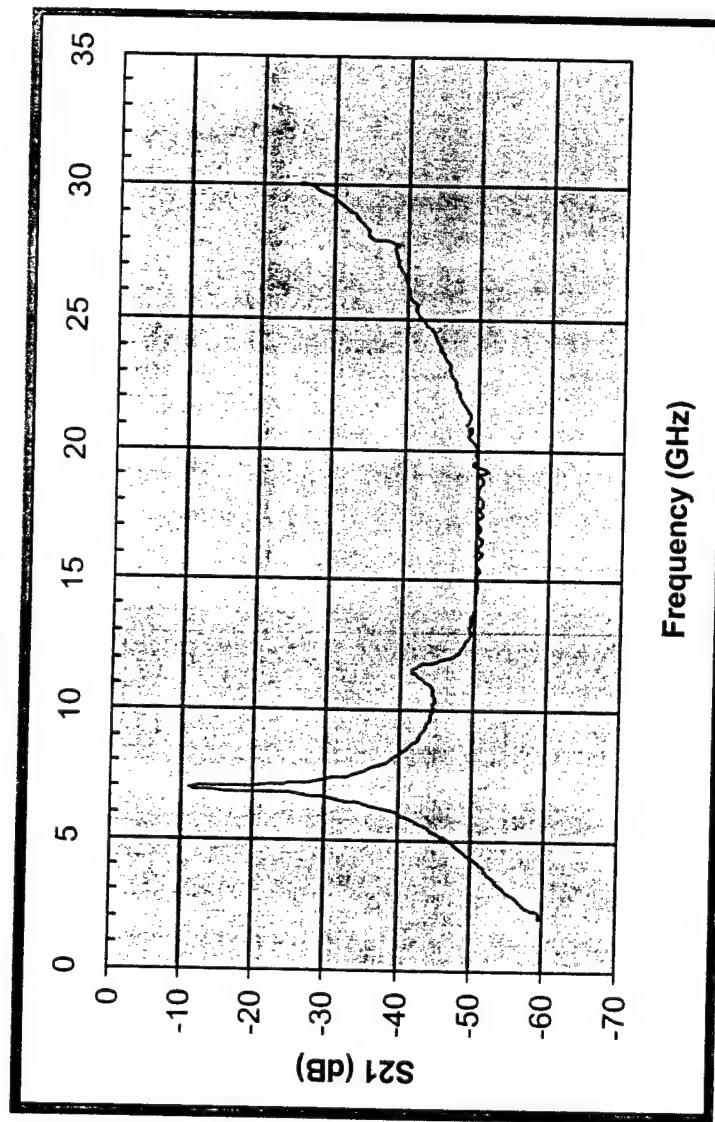
Pattern SiO<sub>2</sub>



Thin SiO<sub>2</sub>



Insertion Loss due to Lines (mm),  $\Omega_1=90$ ,  $\Omega_2=130$

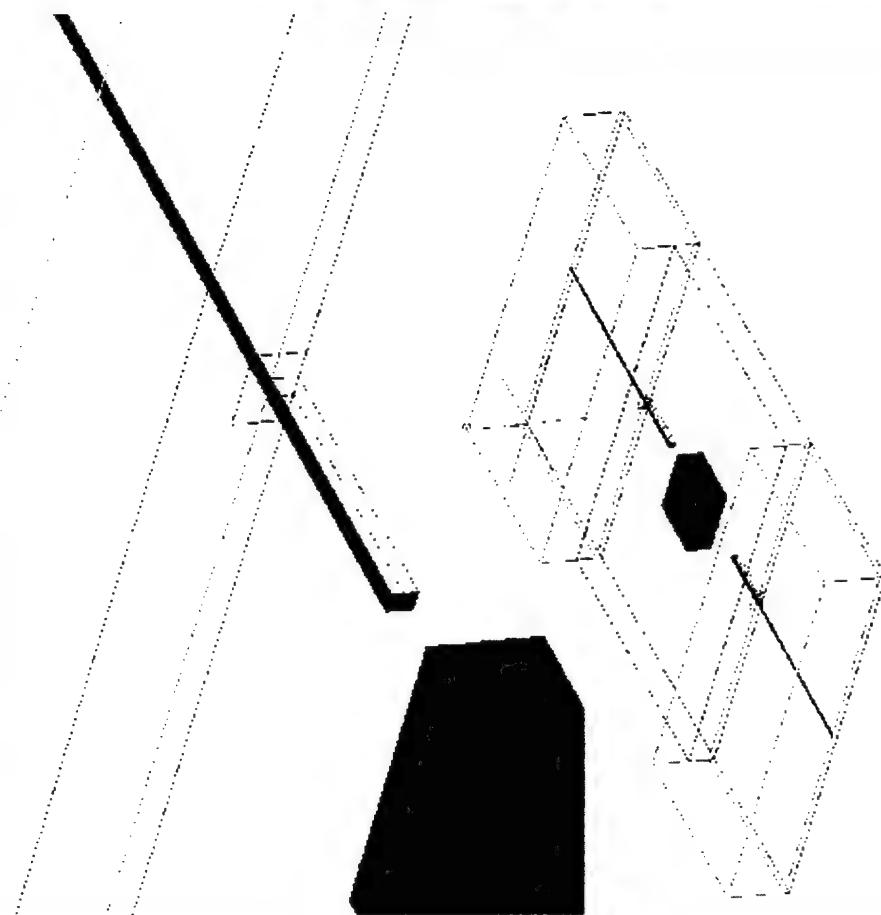
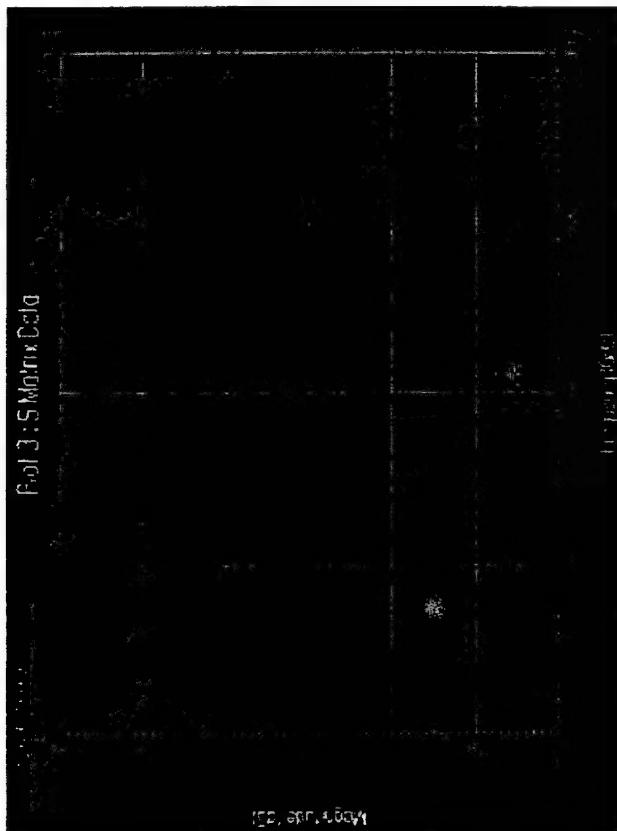


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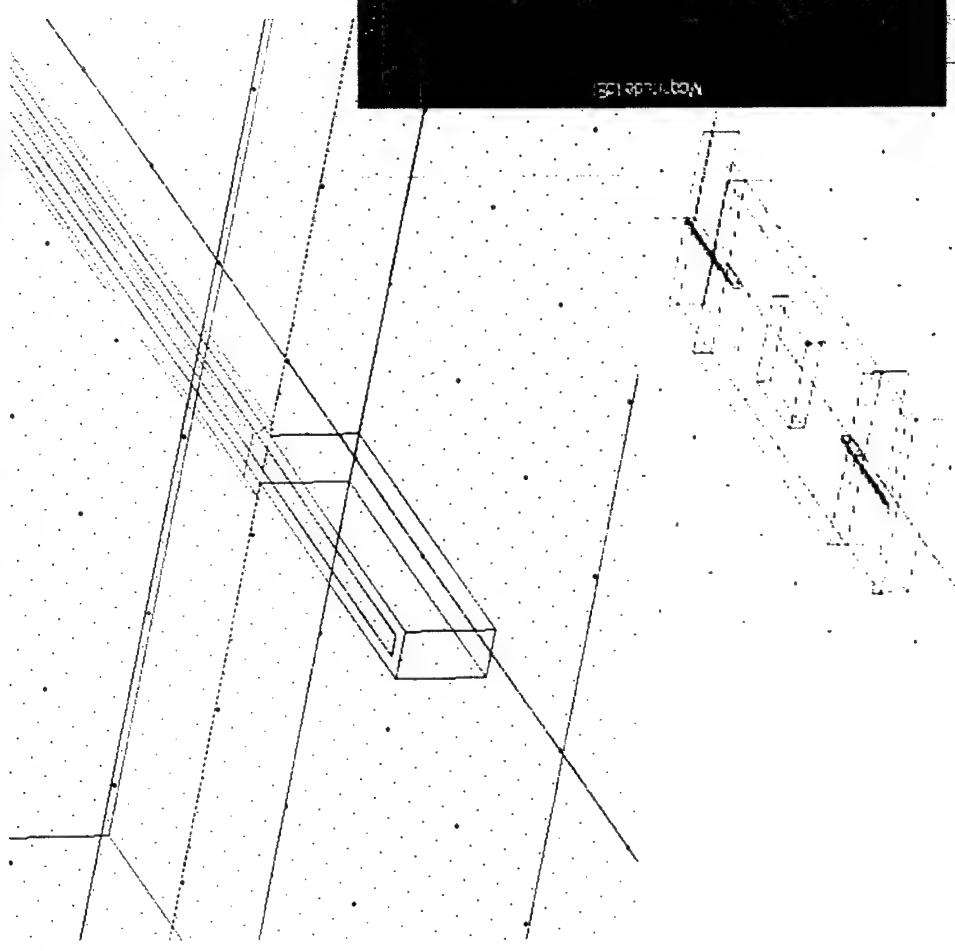
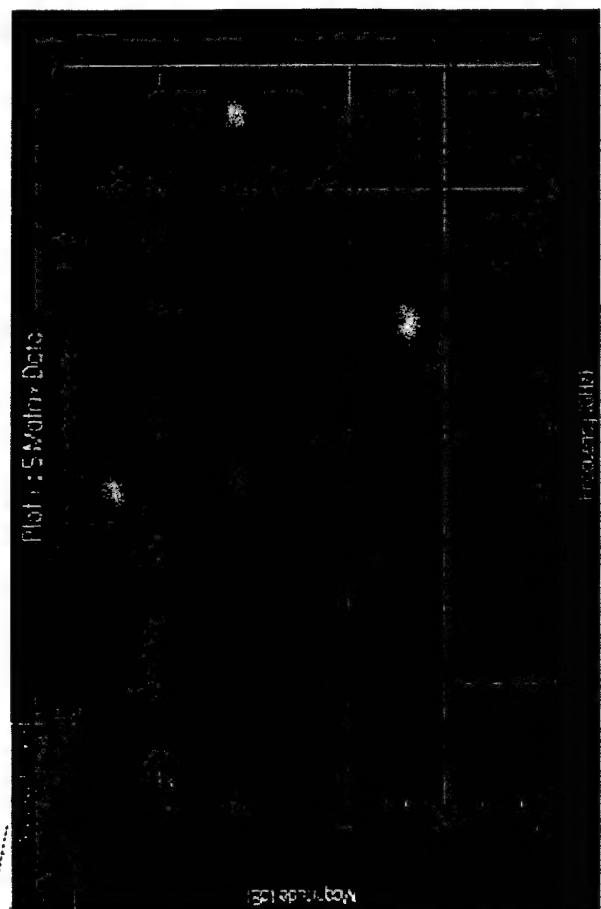
6 by 4 ft  
6 by 4 ft

11x14 ft

102, 6pm, 4000W



size 20 by 16 by 16

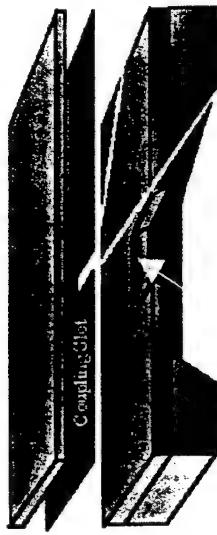
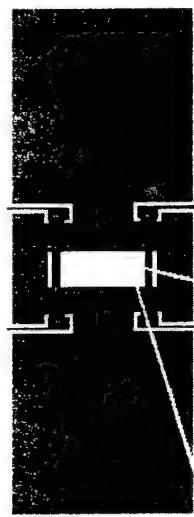


- Tuning External Coupling
- Tuning Post Capacitance
- Tuning of Internal Coupling or  
Evanescent Mode Sections



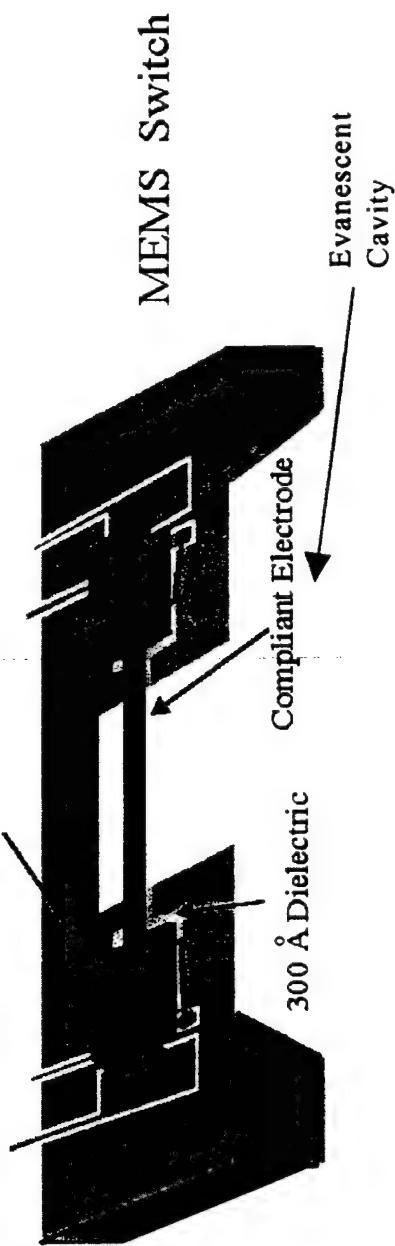


Coupling Slot with Switches



Evanescent Mode  
Cavity

Upper Fixed Electrode





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Michigan  
48106-1183

$W = 60 \mu\text{m}$   
 $G = 40 \mu\text{m}$   
 $f = 30 \text{ GHz}$

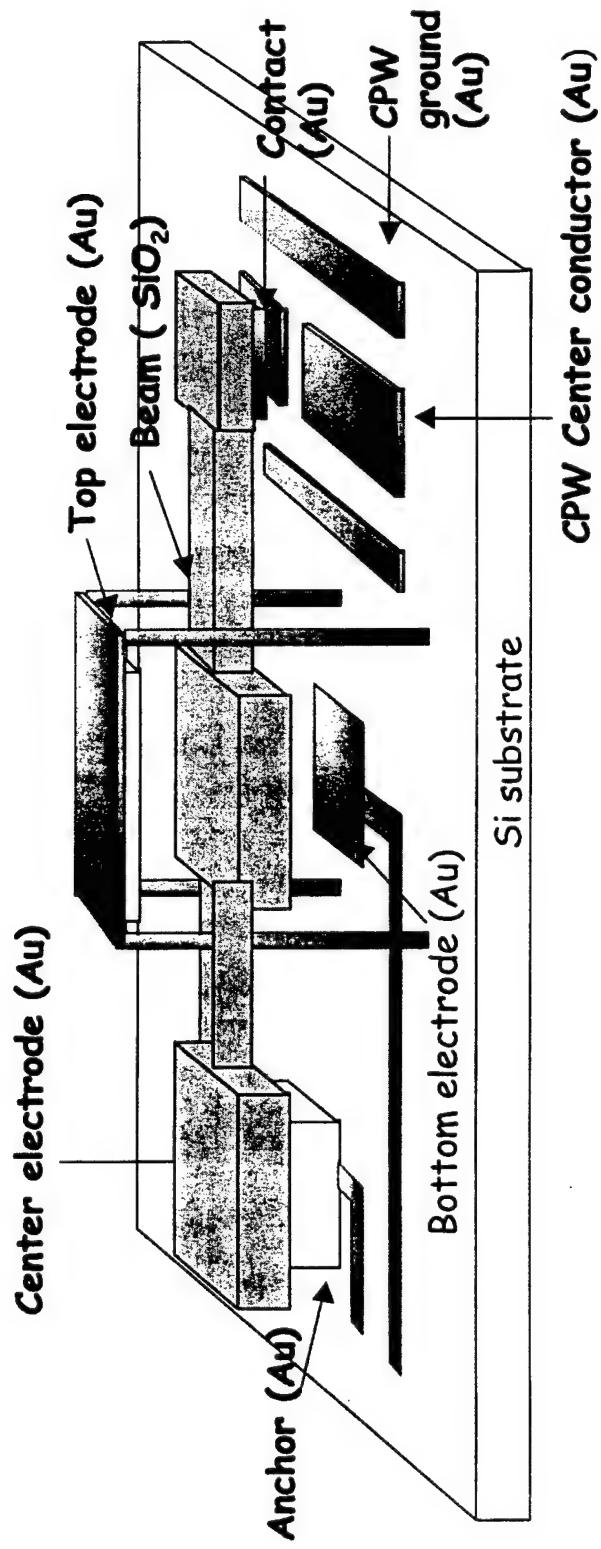
500  $\mu\text{m}$

6

200  $\mu\text{m}$

200  $\mu\text{m}$

10  $\mu\text{m}$



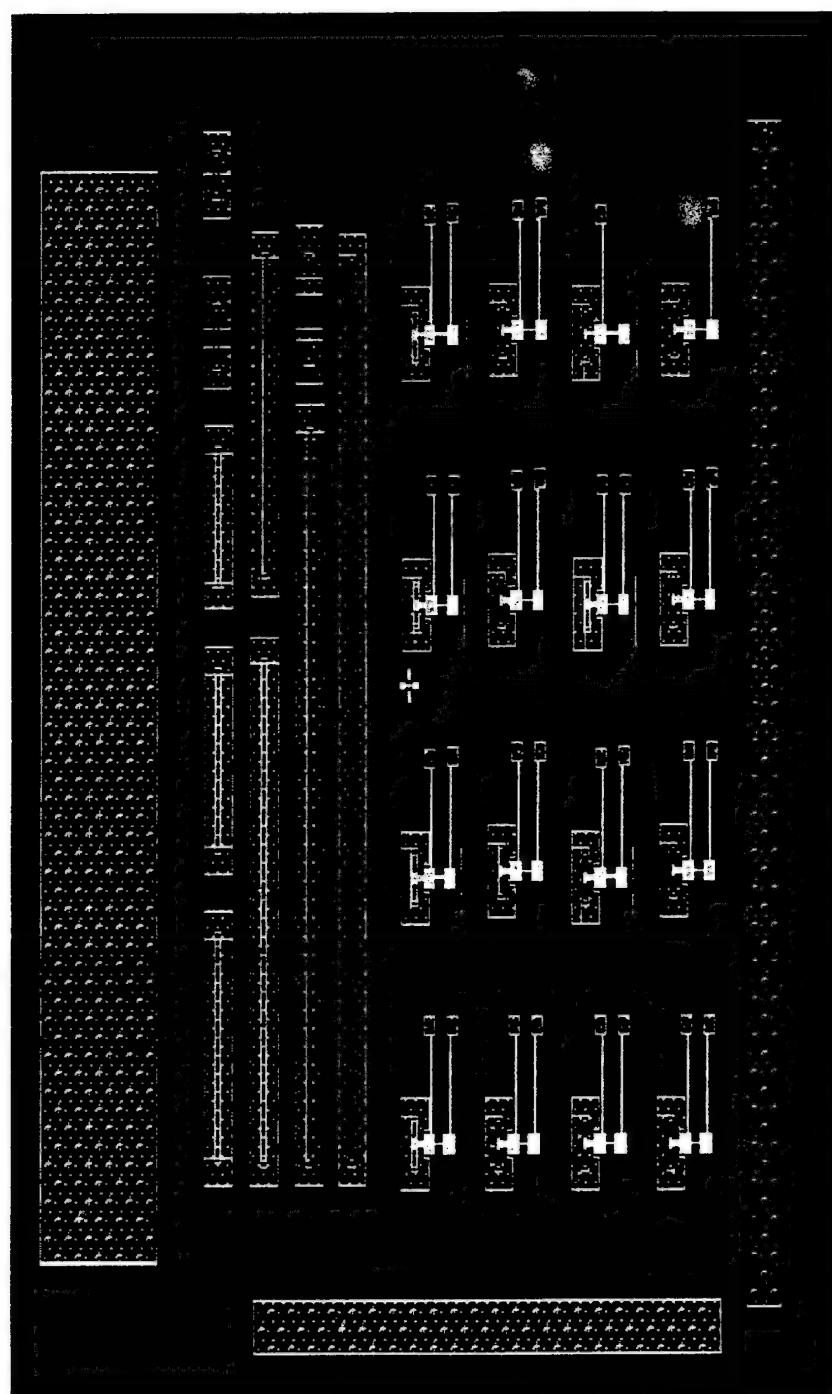


$$k = \frac{WEt^3}{4l^3}$$

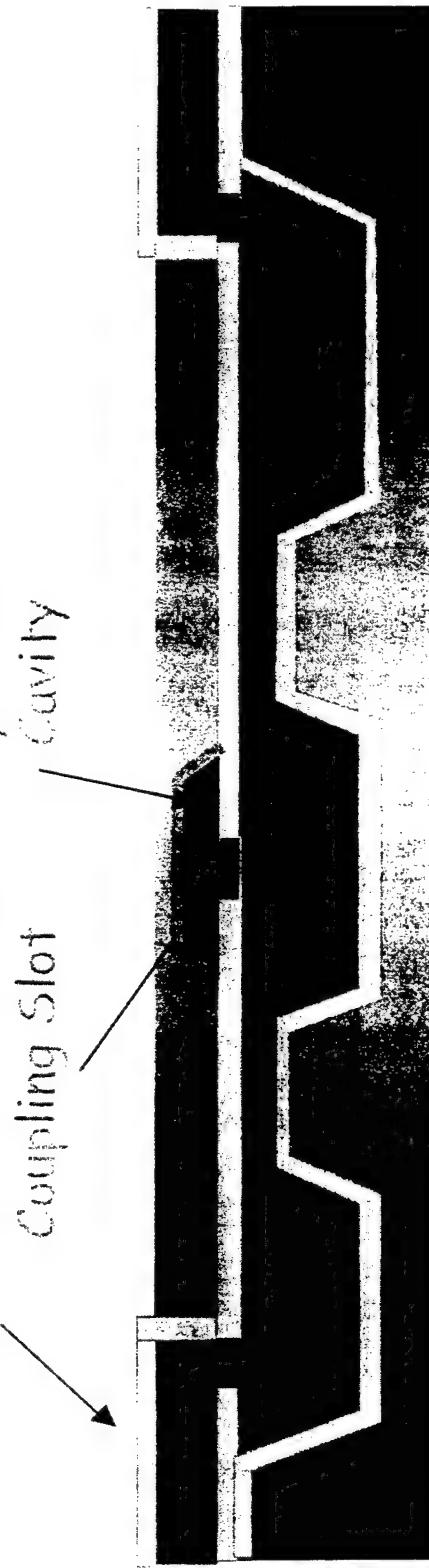
Beam length ( $\mu\text{m}$ )	Beam width = 10( $\mu\text{m}$ )	Beam width = 20( $\mu\text{m}$ )
180	0.24 N/m	0.48 N/m
200	0.18 N/m	0.35 N/m
220	0.13 N/m	0.26 N/m
240	0.10 N/m	0.20 N/m

Beam length ( $\mu\text{m}$ )	Beam width = 10( $\mu\text{m}$ )	Beam width = 20( $\mu\text{m}$ )
180	3.59 V	5.07 V
200	3.06 V	4.33 V
220	2.64 V	3.73 V
240	2.31 V	2.27 V

$$Vpi = \sqrt{\frac{8kd^3}{27\epsilon_0 A}}$$



Microstrip Line Auxiliary Evanescent Field Cavity



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$W = 60 \mu\text{m}$   
 $G = 40 \mu\text{m}$   
 $f = 30 \text{ GHz}$



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- Tip deflection

$$d = \frac{kL^2}{2}$$

$$k = \frac{1}{r} = \frac{6b_1b_2E_1E_2t_1t_2(t_1 + t_2)(a_2 - a_1)\Delta T}{(b_1E_1t_1^2)^2 + (b_2E_2t_2^2)^2 + 2b_1b_2E_1E_2t_1t_2(2t_1^2 + 3t_1t_2 + 2t_2^2)}$$

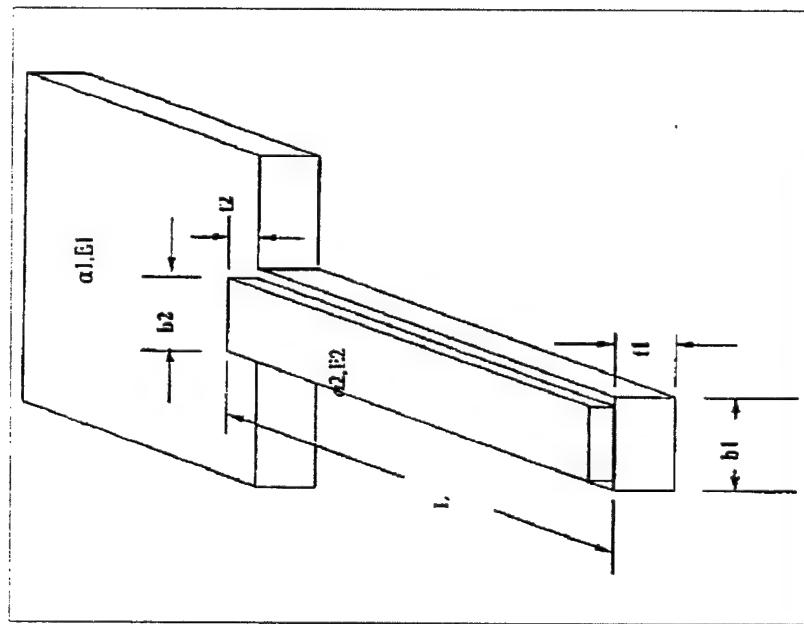
- Max force at the tip of cantilever

$$F = \frac{3EId}{L^3}$$

- Conversion factors :

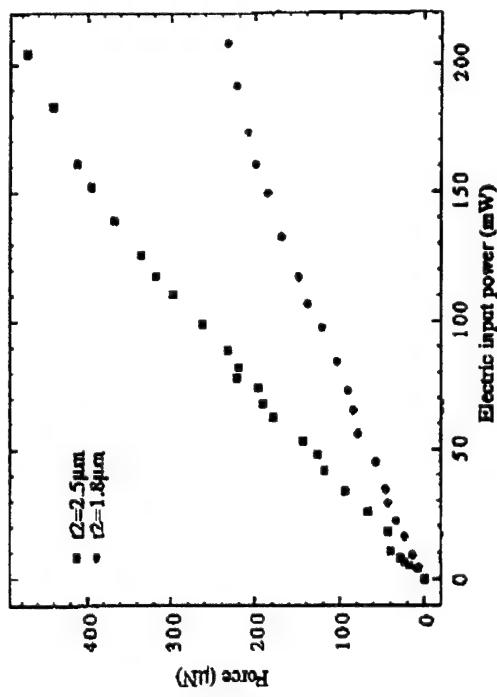
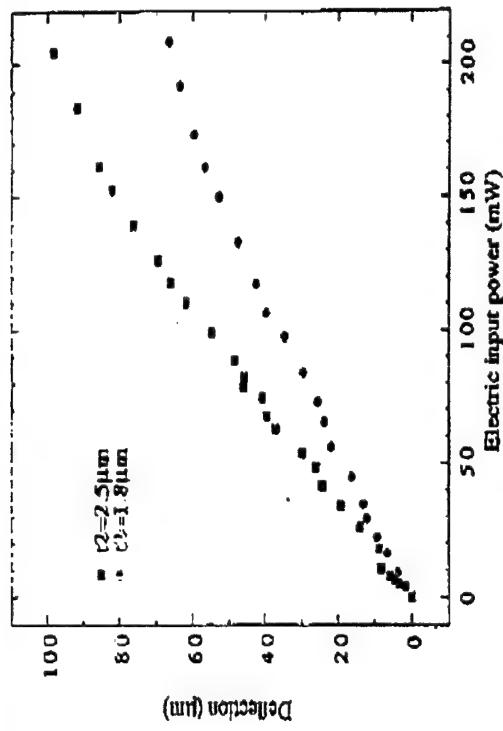
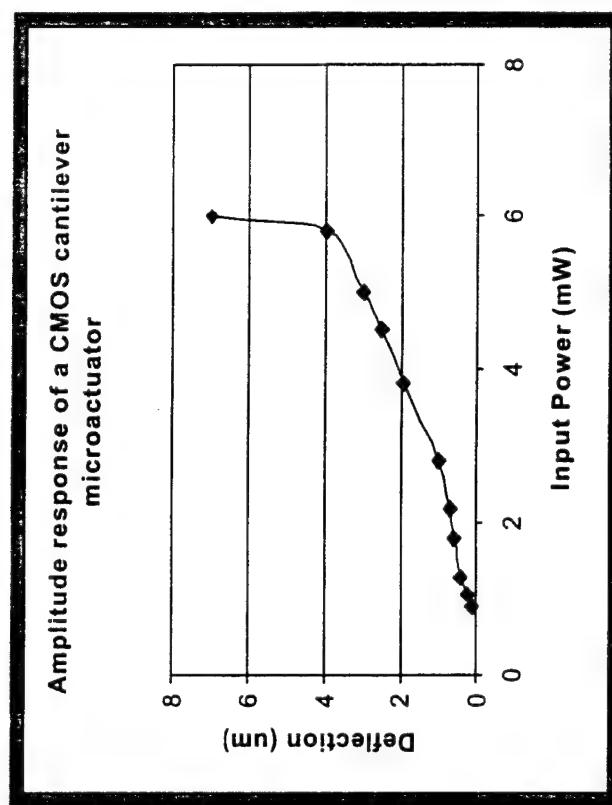
$$\gamma_E = \frac{d}{\Delta T} \quad (\text{e.g. } 0.1 \mu\text{m/K})$$

$$\gamma_E = \frac{d}{P_{IN}} \quad (\text{Typically } 0.5\text{-}1 \mu\text{m/mW})$$





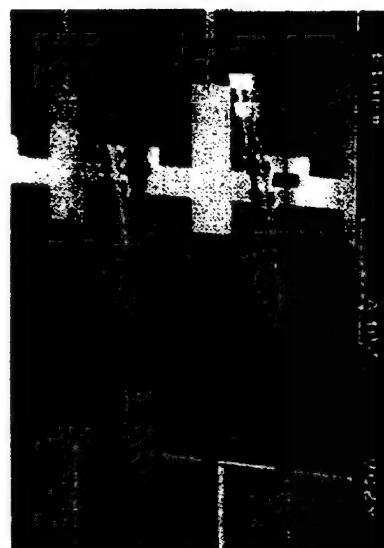
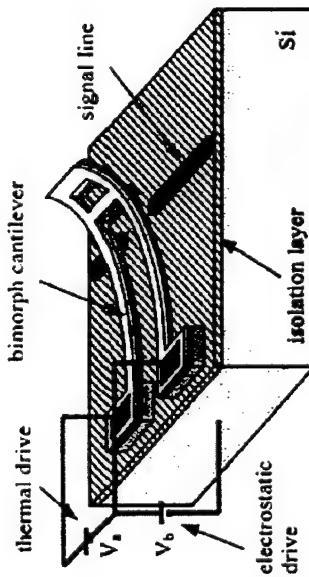
$$L = 170 \mu\text{m} w = 10 \mu\text{m}$$





## Basic Characteristics

- Gold-to-gold electrical contact
  - $R_{ON} = 0.6 - 0.8 \Omega$
  - $L = 328 \mu\text{m}$ ,  $w = 16 \mu\text{m}$
  - Combined thermal and electrostatic actuation
  - Beam :  $\text{TaSi}_2/\text{SiO}_2$
  - Beam deflection : not reported
  - Power (min) : 8.0 mW / 20 V
  - Life time :
    - a)  $10^6$  cycles (hot switching @ 2 mA/2KHz),
    - b) only several cycles (sticking) 5 mA/low frequency





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EECS

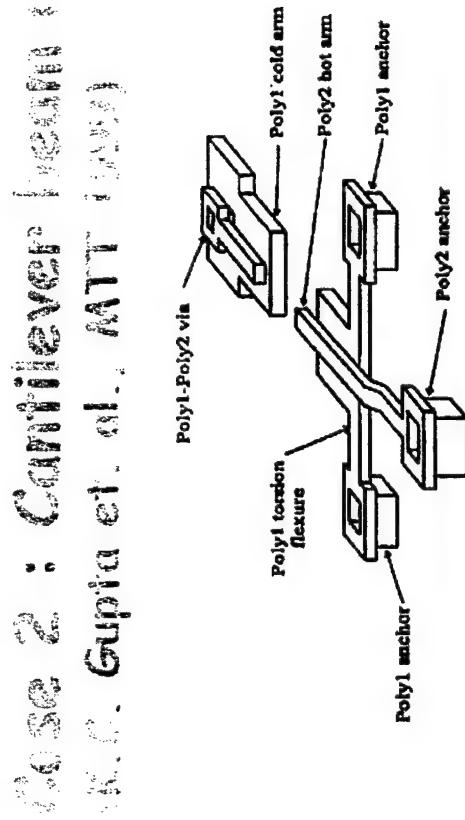


FIGURE 2 : Cantilever beam from  
A. K. Gupta et al., AIT



### Basic Characteristics

- Variable capacitor (5:1)
- No metal-to-metal contact
- $L = 300 \mu\text{m}$ ,  $w = 200 \mu\text{m}$
- Thermal actuation
- Beam : poly-1/poly-2
- Beam deflection :  $1.6 \mu\text{m}$
- Power : not reported (volt : 5V)
- Life time : not reported



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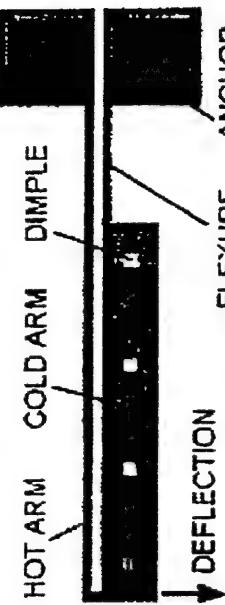
ANN ARBOR

### Design of Microactuators

Table 1  
Best dimensions for unloaded or lightly loaded actuators

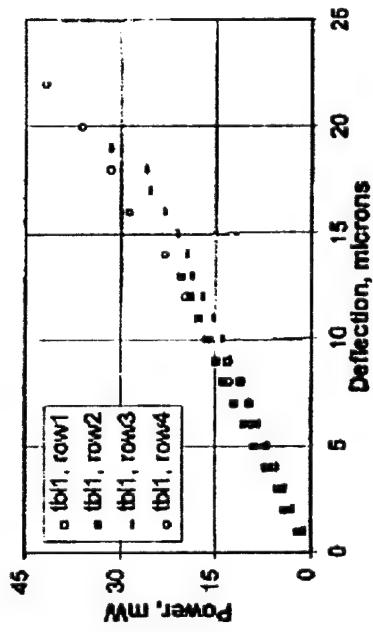
Length	Hot arm width	Flexure length	Gap width	Max. deflection	Max. power (mW)
150	1	30	1.5	9	13
200	1.5	50	1.5	13	21
250	1.5	80	1.5	19	32
300	2	75	1.5	22	42

All linear dimensions are in  $\mu\text{m}$ .



### Basic Characteristics

- $L = 220 \mu\text{m}$ , Whot arm =  $2.5 \mu\text{m}$
- thermal actuation
- Beam : poly hot/poly cold
- Beam deflection :  $\sim 15 \mu\text{m}$
- Power :  $15 \text{ mW}$
- Life time :  $980 \cdot 10^6$  cycles @2KHz





Diaphragm on Up Position



Slit Separating DC Electrodes



Diaphragm in On (DOWN) position



Metallized Cavity Walls



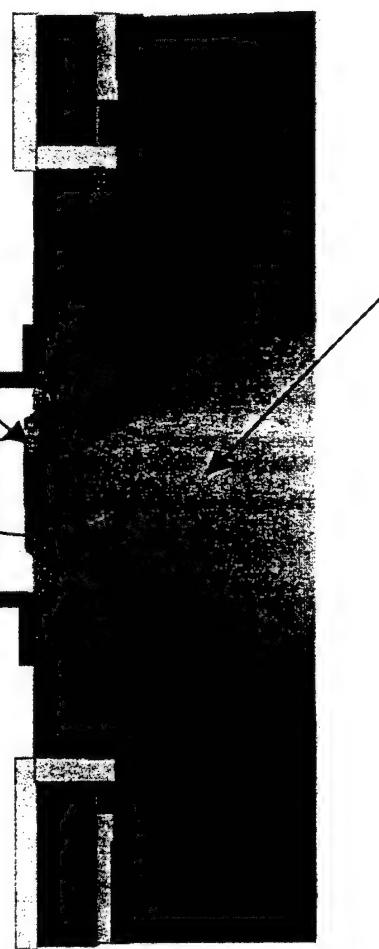
Diaphragm on Down Position



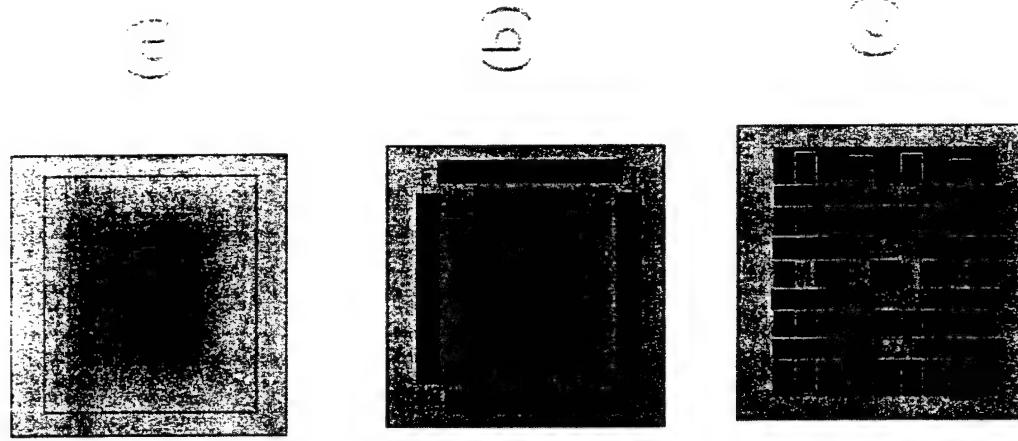
# Types of Diaphragm

Fixed Electrode

Membrane



Capacitive Post





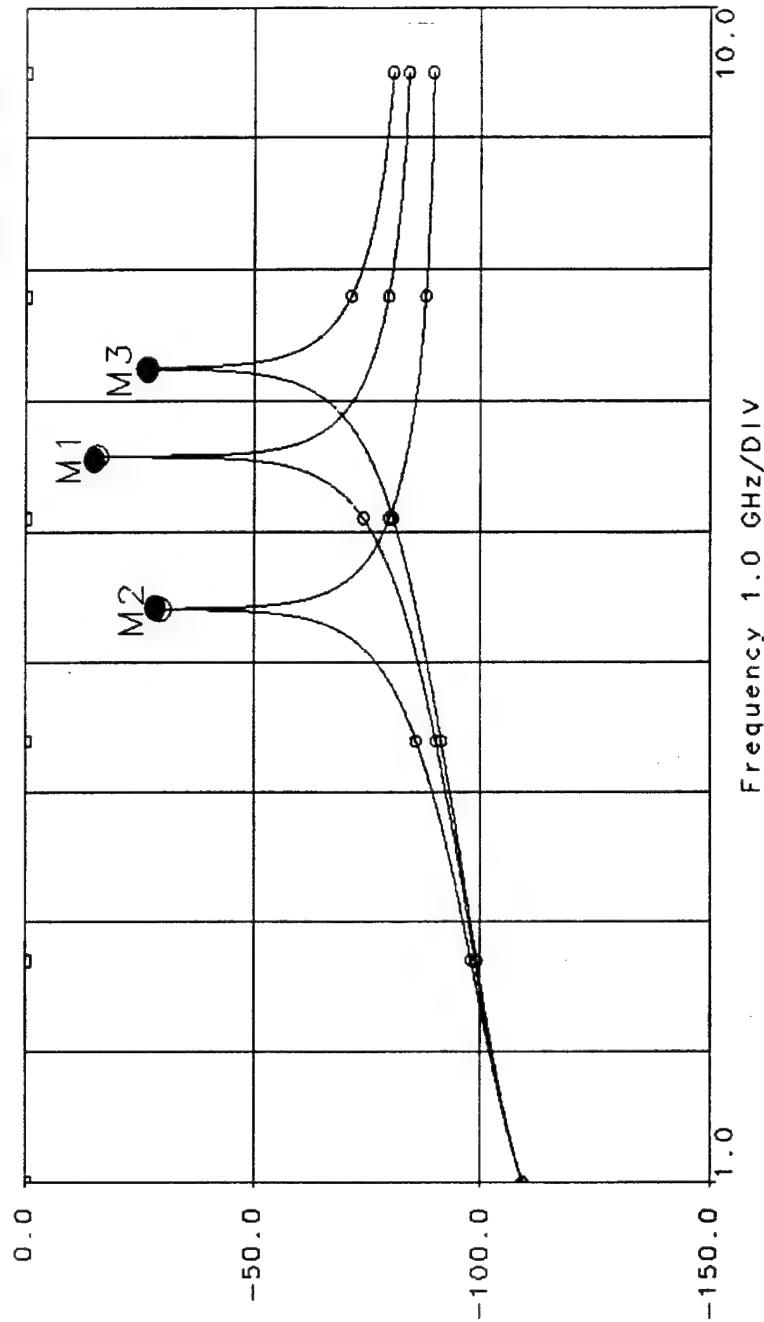
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# Fabrication Tolerance

□ EMF\_Test\_tb  
SMA<sub>1</sub>  
EMR<sub>w</sub>\_Slots  
S[1,1] dB

○ EMF\_Test\_tb  
SMA<sub>1</sub>  
EMR<sub>w</sub>\_Slots  
S[2,1] dB

Post Gap  $g=10 \mu\text{m}$   
Tolerance  $T = 5 \mu\text{m}$



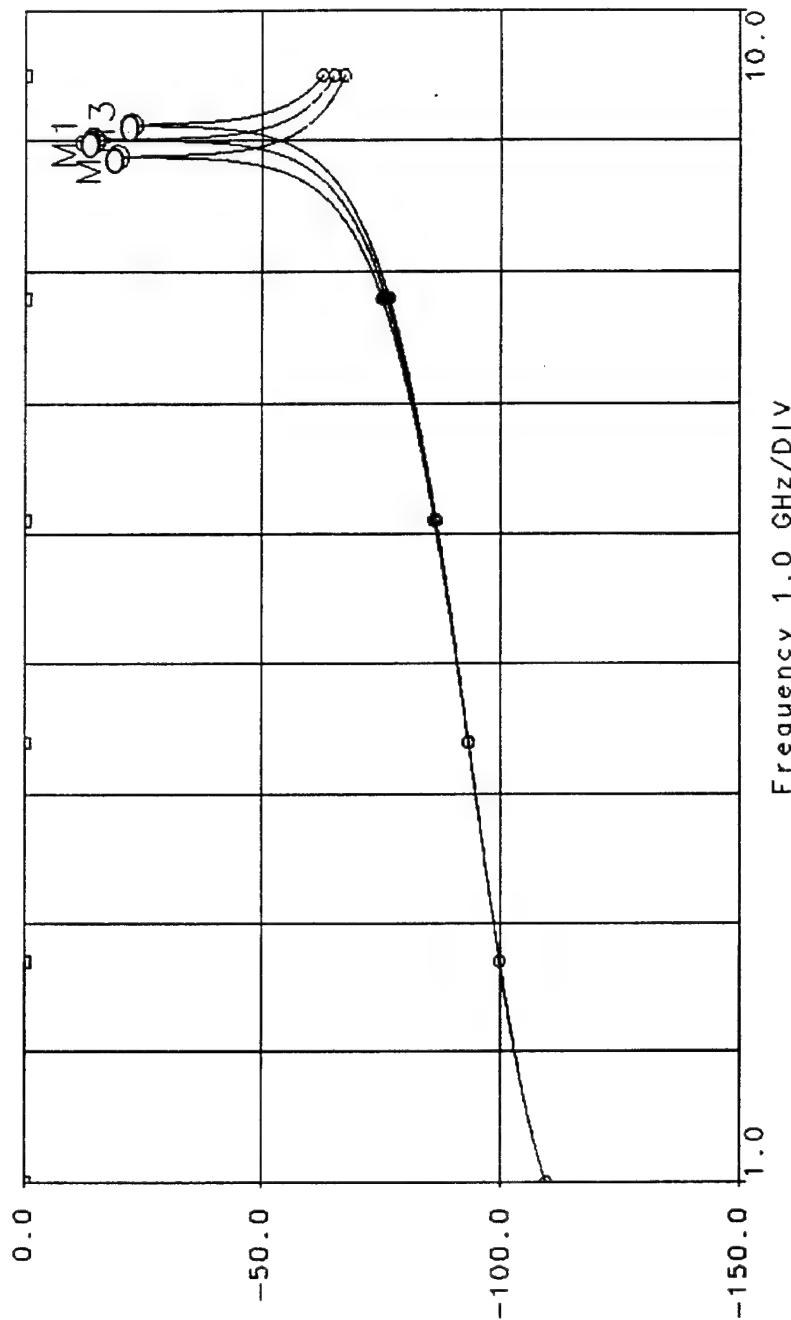


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# Fabrication Tolerances vs. Tuning

□ EMF\_Test\_tb  
SMA\_T1  
EMR\_w\_Slots  
S[1,1]  
dB

Post Gap  
Tolerance

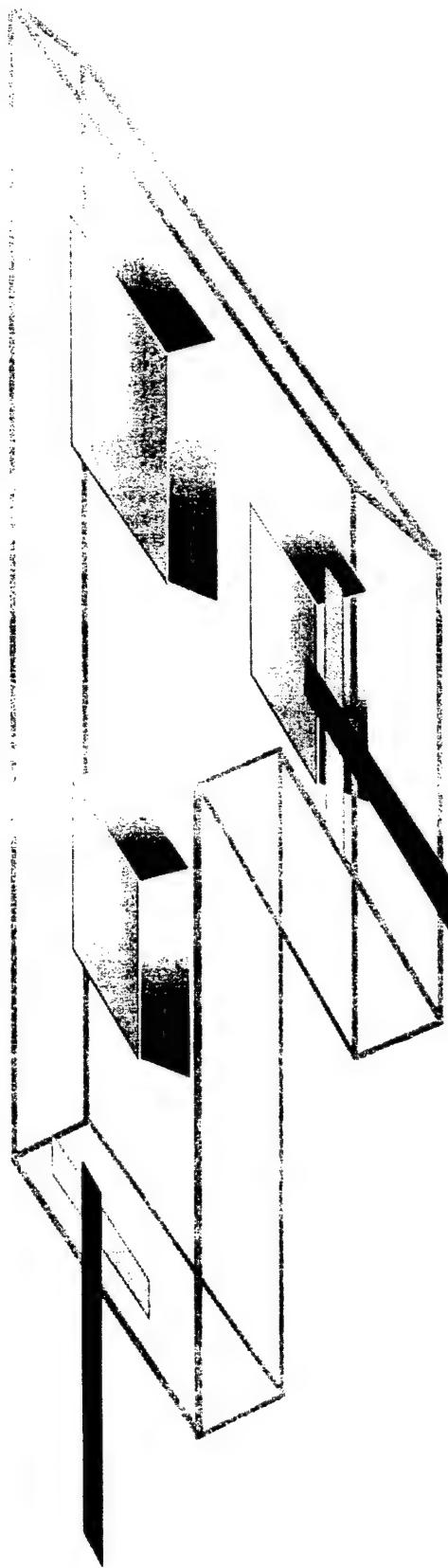




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DETROIT  
CHICAGO  
DETROIT  
CHICAGO

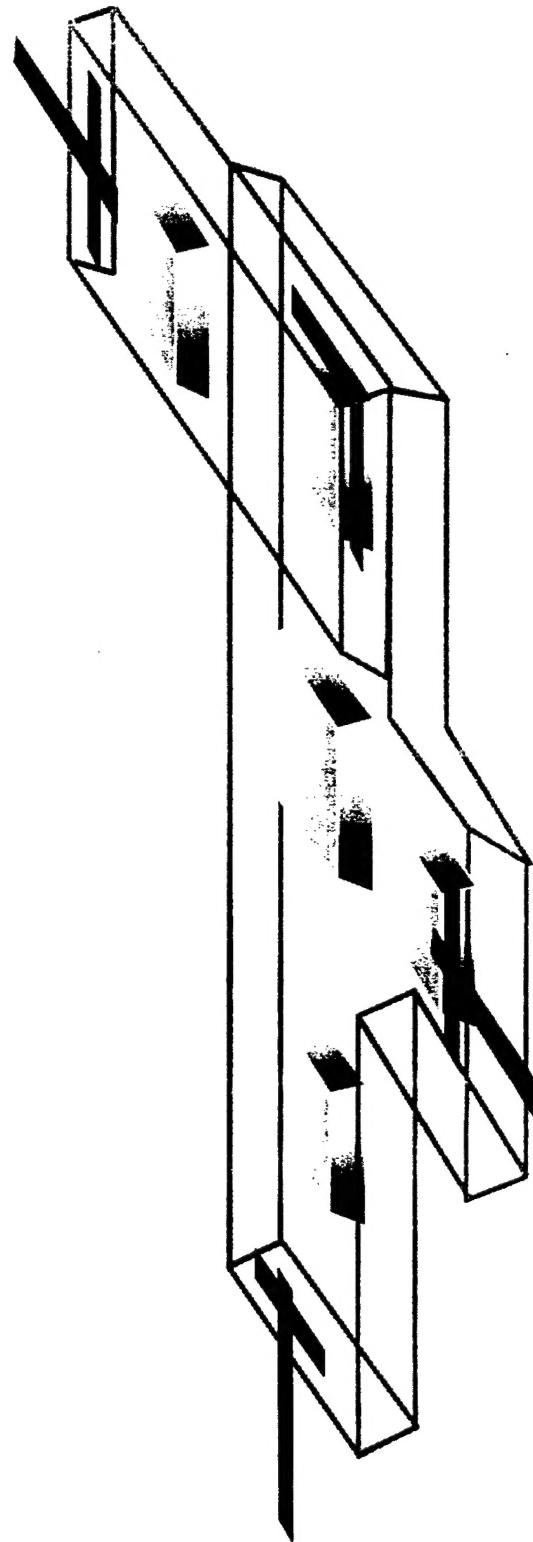




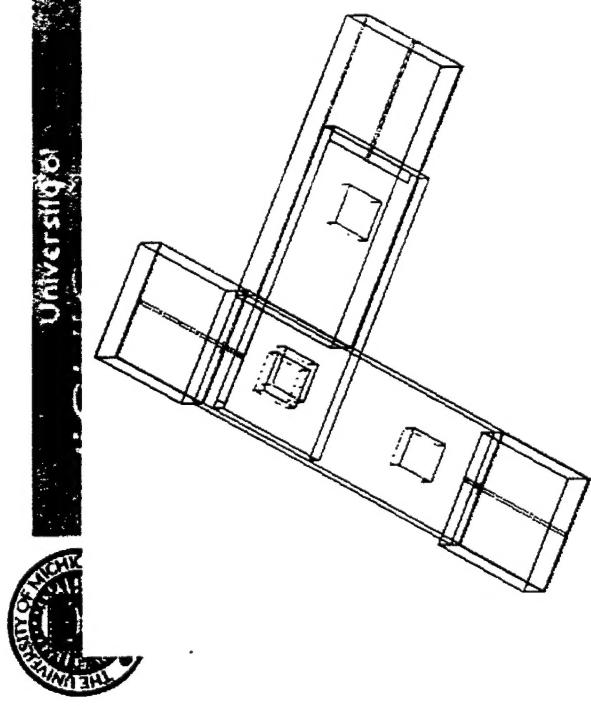
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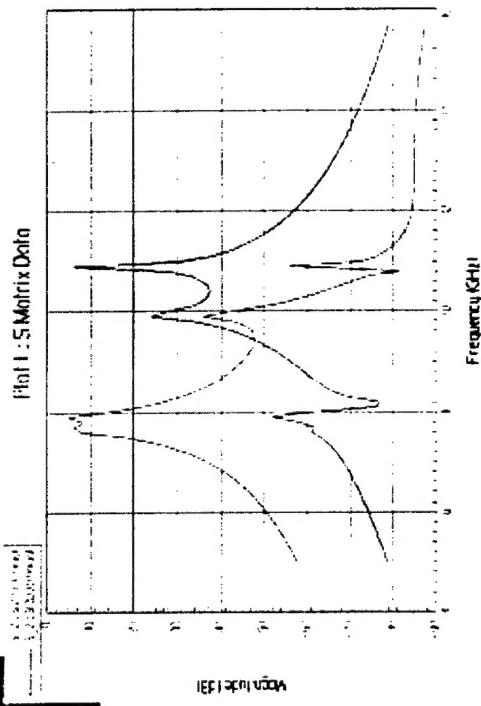
Diploma



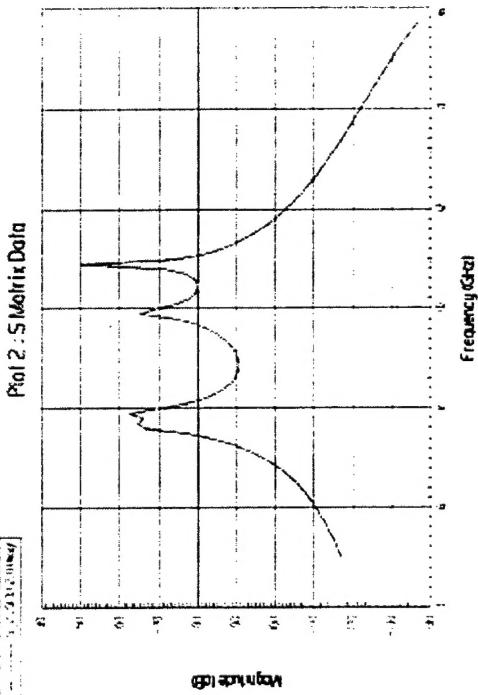
# Diplexer Possibility



Plot 1 : S Matrix Data



Plot 2 : S Matrix Data





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1817

# Accomplishing Evanescent Mode

- Development of a Design Process for multi-pole filters
- Theoretical Simulation of a multipole filter using full-wave techniques to verify method
- Successful comparison to LIBRA
- Demonstration of a single pole evanescent mode filter with 3% bandwidth and Q approximately 400

# March 05 - March 11

March 2001						April 2001					
S	M	T	W	T	F	S	S	M	T	W	F
				1	2	3	1	2	3	4	5
	4	5	6	7	8	9 10	8	9	10	11	12
	11	12	13	14	15	16 17	15	16	17	18	19
	18	19	20	21	22	23 24	22	23	24	25	26
	25	26	27	28	29	30 31	29	30	31	27	28

Monday, March 05		Thursday, March 08	
Linda -Dani needs website (Japan) Linda out of the office Japan		Steve - out of the office	
1:30pm 3:00pm Dean's Cabinet (2267 LEC) 3:00pm 4:00pm Assoc. Deans w/Steve (2267 LEC) 4:00pm 5:00pm Saeed 5:30pm 6:30pm Kamal,Dimitrios,Linda 6:30pm 7:30pm Sergio, Jongming, Clark		8:30am 9:30am Judith Pitney - standing 9:30am 11:30am Faculty Candidates 11:00am 11:30am Multi.Dept Collaboration in High Performance Sci Computing (2210 LEC) 11:30am 12:00pm Ed Borbely - standing mtg 12:30pm 1:30pm NAME Faculty Mtg (232 NAME) 2:30pm 3:00pm Paul - standing 3:00pm 3:30pm Wayne - standing 3:30pm 4:00pm Jim Bean - standing 6:00pm 7:00pm Alex	
Tuesday, March 06		Friday, March 09	
Linda -Dani needs website (Japan) Linda out until 12:00noon		Steve - out of the office (until 3:30)	
9:30am 11:30am Faculty Candidates 3:15pm 5:00pm CoE Chairs Mtg (2210 LEC) 4:00pm 5:00pm Kelly (EECS) 5:00pm 6:00pm Jongming 6:00pm 7:00pm Kok-Yan Lee 7:00pm 7:45pm Eray		8:30am 9:30am Faculty Candidates 10:00am 12:00pm APADG (MI League, Henderson) 2:00pm 3:00pm John Halloran - standing (3062B HH Dow) 4:00pm 5:00pm John W./Kyoung/Ron 5:00pm 6:00pm Pallab Bhattacharya/JPL 6:00pm 7:00pm Kostas	
Wednesday, March 07		Saturday, March 10	
Linda -Dani needs website (Japan) Steve - out of the office		2:30pm 3:30pm Donghoon	
9:00am 11:00am Executive Committee (2267 LEC) 12:00pm 7:30pm GOMAC-Linda to San Antonio for this afternoon 4:00pm 5:00pm Parallelization 5:00pm 6:00pm Jim, Jack, Yonkshil, Phil 6:30pm 7:30pm Bill Chappell and Matt Little			Sunday, March 11